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TABLES

FOR THE

Determination of Common Minerals

1

CHIEFLY BY THEIR

PHYSICAL PROPERTIES

WITH CONFIRMATORY CHEMICAL TESTS.

BY

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PREFACE.

Although the published tables for the determination of minerals are very numerous; yet an experience of five years in the Mineralogical Department of the Massachusetts Institute of Technology, and in the Teachers' School of Science of the Boston Society of Natural History, has convinced me that several important features are wanting in the best tables, for the use of beginners and general students, with which I am acquainted. The primary objects of any system of determinative mineralogy should be: (1) to enable the student to identify certainly and easily such minerals as he is likely to meet; and (2) to cultivate his powers of observation and discrimination, and increase his familiarity with the various species and natural groups of minerals. The first of these primary objects has been, rightly enough, the chief aim of previous tables; but it is to be hoped that, as regards its direct educational value, determinative mineralogy will not always be, as it is now, far behind determinative or analytical botany.

The principal defects of the best tables now in use, so far, at least, as the general student is concerned, are that they have too wide a scope, embracing all or a very large proportion of the known species of minerals, and that the determinations depend almost entirely upon the chemical behavior of the species.

It is scarcely possible to overstate the enormous disparity, as regards their abundance, between the two or three hundred common minerals and the one thousand or more rare species. The former are found abundantly in many localities, and in all good collections, and are, generally speaking, the only species the student will meet or have occasion to identify; while the latter are very restricted in distribution, being often known from only a single locality, occuring for the most part in impure or very minute specimens, and being inadequately represented even in the largest and most complete collections.

The advantages of limiting determinative tables to the common species are that they are then far less voluminous and complicated, the determinations can be made more readily and accurately, and the use of difficult or uncertain tests is avoided. The only disadvantage is that there must often remain the possibility that the specimen in hand belongs to one of the rare species not included in the tables. But, as already explained, this difficulty is very small, and it can not be entirely obviated by the use of the most perfect tables, since it is probable that a large proportion, perhaps a majority, of the rare species are still unknown and unnamed.

Chemical or blowpipe tests are valuable, since the indications which they afford are usually very definite and precise; and since they direct the student's attention particularly to the chemical composition and behavior of the species he is investigating, which is of great importance. Nevertheless, there are several good reasons why they should occupy a subordinate place in a system of determinative mineralogy intended for general use. Not the least of these is their inconvenience, since they require, in the aggregate, a considerable amount of apparatus and re-agents, in other words, a blowpipe laboratory. This consideration, and the knowledge of chemistry which the system demands, practically restricts the instruction to high schools and colleges; and even then the chemical system is not found to be practicable in after life, when the student of mineralogy no longer has access to the facilities afforded by the school. Every teacher of blowpipe analysis must have noted and lamented the fact that, as a rule, the elaborate system so carefully taught is used, after the students leave school, only by the few who become professional mineralogists, chemists or miners.

Perhaps the most serious objection to the chemical tables is that their use has comparatively little tendency to render their aid unnecessary, by making the student more familiar with the external appearance of minerals. Unquestionably, determinative tables are, at the best, a necessary evil. It were far better to recognize minerals on sight, by their structure and physical characters; and, other things being equal, the preference should be given to that system of determination which promises the largest development of this power in the student.

These tables are, then, an attempt to determine about two hundred minerals by their more obvious physical and structural features, with confirmatory chemical tests. The latter will not usually be required when the specimens are pure and well characterized. But they are, as a rule, so simple and decisive that their use is strongly recommended whenever convenient and the determination is not otherwise perfectly satisfactory. Only those tests have been selected requiring the minimum of apparatus, re-agents and previous chemical training, with a view to adapting the tables to the use of common schools and private students.

The various properties of minerals, and all the chemical and blowpipe tests referred to in the tables, are fully explained in the introduction, which also includes an outline of the classification of minerals; so that, although this little work is not in any sense a manual of mineralogy, constant reference to the more comprehensive treatises is avoided.

Boston Society of Natural History,
Boston, November 1, 1886.

INTRODUCTION.

The properties or natural characteristics of minerals, by which they are known and recognized, may be arranged in three classes, as follows:—

1. Properties relating to the form and structure (crystallization, etc.) of minerals—*morphologic properties.*

2. Properties relating to the action on minerals of the various physical forces—*physical properties.*

3. Properties relating to the composition and chemical behavior of minerals—*chemical properties.*

For the sake of convenience, and to indicate their subordinate position in these tables, the chemical properties are placed last, although in a systematic treatise on mineralogy this class would properly come first.

Morphologic Properties or Crystallography.

The principal forms and structures of minerals are those due to their crystallization; but there are other kinds that are quite independent of crystallization. Hence crystallography is only a part, although the main part, of the general science of the forms and structures or morphology of minerals.

Definition of a crystal.—A crystal is a natural solid bounded by plane surfaces symmetrically arranged with reference to certain imaginary lines or directions of growth passing through its centre and called the axes. Most crystals break or cleave with great ease in certain definite directions; and this geometric splitting, or crystalline cleavage, as well as certain optical properties of crystals, proves that crystallization means regularity of internal structure as well as of external form.

Degrees of individualization of Crystals.—Crystals are the mineral individuals, and several degrees of distinctness and perfection of crystallization or individualization are recognized, as follows: When the crystals are distinct or separate and so nearly perfect that their proper forms may be clearly recognized, the mineral is *crystallized.* When we have a confused mass showing crystal-faces or planes and cleavage planes, but no perfect crystals (rock salt and white marble), it is *crystalline* or massive. When crystalline form and cleavage are both entirely wanting to the unaided eye, but the specimen exhibits the phenomenon of double refraction when a thin section is viewed by polarized light (chalcedony), it is *cryptocrystalline* or *compact.* When mineral matter is entirely devoid of crystallization (opal and obsidian) it is described as *amorphous* or wholly unindividualized.

FORMS OF CRYSTALS.—This is the most important and at the same time the most difficult section of crystallography; and the student is particularly recommended to refer to a standard treatise, such as Dana's Text-book of Mineralogy. But little more can be attempted here than an explanation of the terms used in the tables. The numerous forms of crystals are arranged in six systems, based on the relative lengths, positions and numbers of the axes. Each system has a number as well as a name, and in the tables they are indicated by the Roman numerals.

I. Isometric System.—The simplest form in this system is the *cube*, with six square sides or planes. Then comes the *octahedron* with eight triangular planes, the *dodecahedron* with twelve rhombic planes, the *trigonal trisoctahedron* with twenty-four triangular (trigonal) planes, the *tetragonal trisoctahedron* with twenty-four quadrangular (tetragonal) planes, the *tetrahexahedron* with twenty-four triangular planes arranged on the plan of the cube instead of the octahedron, and lastly the *hexoctahedron* with forty-eight planes. All of these forms, except the cube and dodecahedron, may occur with only half the planes developed, giving what are called *hemihedral* (half-faced) forms, which may have distinct names, the hemi-octahedron being also called the *tetrahedron*, etc. In general, both the number and arrangement of the planes are quite plainly expressed in the crystallographic names.

II. Tetragonal System.—The *square* or *tetragonal prism* is the simplest or fundamental form of this system. There is also an eight-sided or *ditetragonal prism*. The end planes of the prisms are called the *basal planes*. The remaining forms are the *square* or *tetragonal pyramid*, resembling the octahedron of the isometric system, lengthened or shortened in the direction of one axis, and the *ditetragonal* or eight sided *pyramid*. The crystallographic pyramid is double, being equivalent to two geometric pyramids placed together, base to base, and containing, in each case, twice as many planes as the name indicates.

III. Hexagonal System.—In this system, as the name implies, the fundamental form is the *hexagonal prism*. The holohedral forms are strictly analogous to those of the tetragonal system. Thus we have the *hexagonal* and *dihexagonal prisms*, *basal planes*, and *hexagonal* and *dihexagonal pyramids*. The most important of the hemihedral forms are the *hemihexagonal pyramid* or *rhombohedron*, a form bounded by six rhombic planes and resembling an oblique cube; and the *hemidihexagonal pyramid* or *scalenohedron*.

IV. Orthorhombic System.—The fundamental form here is the *ortho* (right) *rhombic prism*, which gives the name to the system. Then comes the right rectangular prism, consisting of two narrow planes called *brachypinacoids* and two broad planes called *macropinacoids*. The two end planes as before, are the *basal planes*. The eight

inclined or sloping planes corresponding in position to the orthorhombic prism planes make the *orthorhombic pyramid*; while the four inclined planes corresponding to the brachy and macro pinacoids, respectively, are the *brachy* and *macro domes.*

V. Monoclinic System.—This system is essentially similar to the last, except that one of the axial intersections is oblique, so that the forms all incline in one direction (monoclinic). The prefixes of the names pinacoid and dome are *ortho* and *clino*, instead of macro and brachy; and we call the prism and pyramid *monoclinic* instead of orthorhombic.

VI. Triclinic System.—The forms of this system are analogous to those of the fourth and fifth systems; but are easily distinguished by the fact that the angles are all oblique.

When all the planes on a crystal are of one kind, it is described as a simple form and given one crystallographic name. But when they are of two or more kinds it is called a compound form and requires for its accurate description as many crystallographic names as there are kinds of planes. Thus, on the ordinary crystal of quartz there are two kinds of planes, and we describe it as a combination of the hexagonal prism and the hexagonal pyramid.

These compound *forms* must be carefully distinguished from the compound or double (*twin*) *crystals.*

The quartz crystal, although described as a compound form, because there are two forms or kinds of planes, is a single, simple crystal. But if two such crystals should grow together in a regular and definite manner, the result would be a double or twin crystal.

STRUCTURE OF CRYSTALS.—The only topic that we need notice under this head is the regular splitting exhibited by most crystals—*crystalline cleavage*, which is scarcely less important to the student of determinative mineralogy than the external forms of crystals.

Amorphous bodies, such as glass and opal, being essentially homogeneous, possess no planes of least cohesion, but are equally strong in all directions. Consequently, when broken they yield fragments of very irregular forms. But the regular molecular structure of crystals, as already stated, is usually indicated by definite directions of easy splitting or cleavage; so that the fragments present on one or more sides flat lustrous surfaces. The cleavage is independent of hardness, being almost equally perfect in diamond and talc, the hardest and softest of minerals.

The cleavage directions or planes are always parallel to some actually occurring, or to some possible, external planes of the crystal; and are usually limited to the simpler forms in each system. Consequently it is often possible to determine all the more important features of the crystallization of a mineral from the examination of small cleavage fragmetns.

There are different degrees of cleavage. When the mineral splits very easily, yielding smooth and brilliant surfaces, like mica, the cleavage is *perfect* or *eminent*; and the inferior degrees are described as *distinct, indistinct* or *imperfect, interrupted, in traces, difficult*, etc.

The different cleavage directions are named after the external planes of the crystal with which they are parallel. Thus, in the isometric system we have *cubic, octahedral* and *dodecahedral* cleavage. The principal kinds of cleavage in the other systems are the *prismatic, basal* and *pyramidal*, besides the *rhombohedral* cleavage of the third system and the *pinacoidal* cleavages of the fourth, fifth and sixth systems.

FORMS AND STRUCTURES OF MINERAL AGGREGATES.—Minerals frequently occur in masses having a more or less definite external form and internal structure, the form and structure of which are not due wholly, if at all, to crystallization, *i. e.*, to a regular geometric arrangement of the mineral molecules, but are the product, in part at least, of forces different from those by which crystals are made.

These masses or aggregates are usually uncrystalline, and are never single crystals, or regular compounds of crystals.

External Forms of Mineral Masses.—When mineral matter is deposited in parallel layers on uneven surfaces, the upper surface of the deposit, like snow that has fallen on uneven ground, presents smoothly rounded hummocks or elevations. If these are small and somewhat grape-like in outline, the form is described as *botryoidal.* When the rounded prominences are larger, the form is called *mammillary.*

Closely related to these deposition forms, are those produced when water holding mineral matter in solution falls, drop by drop, from an overhanging surface of rock. The pendant cone or column thus produced is called a *stalactite*, and the form is described as *stalactitic.* The low mound or layer made by the water dripping from the point of a stalactite upon the rocky floor below is called a *stalagmite*, the adjective term being *stalagmitic.*

The porous deposit formed when reeds, grass, moss, and other kinds of vegetation are encrusted by mineral solutions is called a *tufa*, and its form and structure are described as *tufaceous.*

A rounded mass or nodule produced by the segregation of mineral matter in the mass of a rock is called a *concretion*, the form being *concretionary.* If the concretions are small, about like peas, the form is called *pisolitic*; but if they are as small as mustard seed it is *oolitic.* Hollow concretions are called *geodes.* The *amygdaloidal* (almond-like) form results from the deposition of mineral matter in the vescicles or steam-holes of lava. In the stains of iron and manganese oxides known as *dendrite*, in moss agate, often in native copper, and on a frosted window-pane, we have forms which are called *dendritic, arborescent*, and *mossy.* These are usually more or less dependent upon the crys-

tallization; and from these we pass easily to the *reticulated* and *plumose* forms. The native metals, especially, occur in wire-like or thread-like shapes, and are described as *filiform* or *capillary*; while slender, needle-like crystals are *acicular*. When a surface is thickly set with crystals of a uniform size, they are described as *implanted crystals*; and when the implanted crystals are very small the form is called *drusy*.

Internal Structures of Mineral Masses.—We have first the different kinds of *granular* structure. The grains are usually merely small, imperfect crystals, and there is a perfect gradation from the most *coarsely* to the most *finely* granular kinds. When the grains become invisible to the naked eye the structure is *compact* or *impalpable*; and when no trace of a granular structure can be detected, even with the microscope, the mineral is *glassy* or *vitreous*. In this state it may be crystalline, like vitreous quartz, or amorphous, like obsidian.

The *lamellar* structures come next in importance. We properly distinguish at the outset those masses in which the lamination is entirely independent of crystallization, from those in which it is not. In the first class this structure is commonly described as *banded*, and in the second as *foliated*. The *banded* structure occurs commonly with the botryoidal, stalactitic, stalagmitic, and geoditic forms, and the layers may be straight (plane) or curved and concentric. The *foliated* structure, on the other hand, is simply an easy splitting in parallel planes due to very perfect cleavage in one direction. This cleavage is usually basal; and foliation has its best development in the micas and allied minerals.

The *fibrous* structure is the third principal kind. It also depends upon the crystallization; for, as we may usually regard the granular masses as aggregates of short, thick crystals; the foliated masses as aggregates of flat, tabular crystals; so the fibrous masses may be regarded as examples of very slender, attenuated crystallization—prismatic crystallization carried to an extreme. When the fibres are large and distinct the structure is called *columnar* or *bladed*.

In the tables, not only the system in which the mineral crystallizes, but any marked habit of crystallization, and its more characteristic uncrystalline or massive forms are briefly indicated.

Physical Properties.

The topics to be considered here are those characteristics of minerals depending upon their relations to the physical forces, such as cohesion, elasticity, light, heat, electricity, etc.

Properties relating to Cohesion and Elasticity.—*Cohesion* is the resistance which any body offers to a force tending to separate its molecules or particles, either by breaking or abrasion. The principal properties relating to this force are, *cleavage*, *fracture* and *hardness*.

Elasticity, on the other hand, is the force which tends to bring the molecules of a body back into their original positions when they have been disturbed. Upon elasticity depends, for the most part, the degrees of tenacity possessed by different minerals.

Cleavage and Fracture.—When minerals are broken, if the divisions are determined in direction and character by the crystallization, yielding smooth, plane surfaces parallel to the external planes of the crystal, the breaking is called *cleavage*; but if the divisions are independent of the crystalline form, and usually more or less irregular, the breaking is called *fracture*.

Although cleavage planes are directions in crystals along which the molecules separate readily, and cleavage is, in this respect, evidently related to cohesion, yet it is far more important as a manifestation of the molecular structure of crystals; and its characteristics have, therefore, been described in the preceding section (see page 5). When the cleavage is perfect, true fracture is difficult to obtain, on account of the strong tendency of the breaking to follow the directions of least resistance, *i. e.*, the cleavage directions. The most important kinds of fracture are: the *conchoidal*, the mineral breaking with curved concavities resembling the valve of a shell; the *even*, when the surface of the fracture is approximately smooth; the *uneven*; the *earthy*, breaking like clay or chalk; and the *hackley*, *splintery*, etc. In the tables, the fracture is given, only where the cleavage is very imperfect, or entirely wanting.

Hardness.—The hardness of a mineral is the resistance which it offers to abrasion. Hardness, however, is a purely relative term, and hence mineralogists have found it necessary to select certain minerals to be used as a standard of comparison for all others. This scale of hardness consists of ten minerals showing a regular gradation in hardness from talc, which is one of the softest of minerals, to diamond, the hardest of all minerals, as follows:—

1. Talc.
2. Gypsum.
3. Calcite.
4. Fluorite.
5. Apatite.
6. Orthoclase.
7. Quartz.
8. Topaz.
9. Corundum.
10. Diamond.

Arranged in this order, each member of the scale is harder than (*i. e.*, will scratch) all that come before it, and is softer than (*i. e.*, is scratched by) all that come after it. The degree of hardness possessed by any mineral may be determined by direct comparison with the scale, and is expressed by the number, rather than the name, of the member of the scale to which it corresponds. Thus, if it does not scratch orthoclase, and is not distinctly scratched by orthoclase, its hardness is 6. If it scratches fluorite, but is scratched by apatite, its hardness is between 4 and 5; and it is possible, by making the

test carefully to determine whether it is about 4.25, 4.5 or 4.75.

Although it is important that the student should be acquainted with the scale of hardness, and understand how to use it, it is not essential for the determination of common minerals. Very few common species have hardness above 7; and hence for all ordinary purposes the thumb-nail, a knife or file and a piece of quartz are sufficient. In the column marked "H," in the tables, the exact, or where variable the average, hardness of each species is given, so that careful comparisons may be made when desired. But an examination of the analytical key on the left margin of each table, or of the general classification of the tables, will show that the determinations are based upon a scale of hardness embracing only five degrees, as follows:—

1. Very soft (below 2.5); can be scratched with the nail, or very easily with the knife.
2. Soft (2.5–4); cannot be scratched with the nail, but easily scratched with the knife.
3. Hard (4–6); can be scratched with the knife, but not easily.
4. Very hard (6–7); cannot be scratched distinctly with the knife, but is scratched by quartz.
5. Adamantine (above 7); cannot be scratched by quartz.

The figures in the parentheses give the corresponding degrees of the regular scale.

The great advantage of this scale, which, of course, is recommended only for the determination, and not for the description, of minerals, is its convenience, combined with a reasonable degree of accuracy. The adamantine minerals, or those having hardness above 7, are all found in one small group at the very end of the tables. Hence, in nearly all cases the quartz will not be required, the knife and thumb-nail being sufficient; and a little practice will enable the student to determine whether a mineral that can be scratched with the knife scratches easily or with difficulty. The doubtful or variable minerals are repeated in all the sections of the tables to which students would be likely to assign them. It is important, however, to note that beginners usually overestimate the hardness of minerals; and that a sharp angle will usually slightly scratch a flat surface of the same mineral. The student will also learn to make allowance for foreign substances or impurities.

Tenacity.—All solid minerals may be classed as either *brittle* or *flexible*. Brittle minerals, to which class the majority belong, are those whose forms can not be sensibly distorted without rupture. The degree of cohesion, however, varies greatly; some brittle minerals being very rigid or strong and breaking with great difficulty, like corundum; while in the typical brittle minerals, such as quartz and calcite, the cohesion is less and a moderate blow suffices to break them. But the

minimum cohesion is found in the friable minerals, which are at once very brittle and very easily broken. Brittle minerals, in other words, are those which break suddenly under a blow, and whether the blow needs be light or heavy is immaterial.

Flexible minerals, on the other hand, are those whose forms can be sensibly distorted without rupture. All flexible minerals are also *sectile*, *i. e.*, can be cut without breaking or crumbling. All brittle minerals are elastic, and the elastic flexible minerals, such as mica, are those possessing the least flexibility in pieces of ordinary thickness, constituting an intermediate class between the brittle and flexible minerals. The typical flexible minerals are malleable and ductile as well as sectile. As in the brittle class, the degree of cohesion varies greatly, as is seen by comparing iron and copper with gypsum and talc.

PROPERTIES RELATING TO MASS AND VOLUME.—All that we have to consider here is the ratio of the mass and volume in minerals, *i. e.*, the density or

Specific Gravity.—By the specific gravity of a mineral we mean its weight compared with the weight of an equal volume of water. Although this property is quite as fundamental and constant as hardness, it is less useful in the determination of minerals, on account of the greater difficulty of measuring it with the same degree of accuracy. The specific gravity of solid bodies is usually determined as follows:— The specimen is first weighed carefully on a good balance; it is then suspended from one pan of the balance by a thread or fine wire in a glass of water, and while hanging freely and completely immersed, its weight is taken again. The second weight is subtracted from the first. The difference, or loss by immersion, is the weight of a volume of water equal to that of the specimen; and by dividing this weight into the first weight of the specimen, the desired ratio is obtained. For example, a piece of quartz weighs 25 grains in air, and 15.57 grains in water. $25-15.57=9.43$ grains, the weight of an equal volume of water. $25\div 9.43=2.65$, the specific gravity of quartz.

Minerals exhibit a wide range in specific gravity, from petroleum, which floats on water, to gold, which is nearly twenty times heavier than water. Very few minerals, however, are heavier than iron (7.5) and still fewer are lighter than sulphur (2.), the great majority falling between 2.5 and 5. But, notwithstanding this narrow range, the student can, with practice, learn, by merely lifting specimens, to estimate the specific gravity accurately enough to make it a very valuable aid in the determination of many minerals. This property is relied upo to some extent, in the analytic key of the tables, for distinguishin groups of minerals. The caution with regard to impurities, given i the preceding section, might be repeated with additional emphasis here

PROPERTIES RELATING TO LIGHT.—On account of their comparatively superficial nature and the consequent ease with which they may be ascertained, the optical properties play a very important part in determinative mineralogy.

Lustre.—By the *lustre* or *glance* of a mineral is meant the quantity and quality of light reflected by it, as determined by the character or minute structure of its surface. Variations in the nature of the reflecting surface, produce different *kinds* of lustre; and variations in the quantity of light reflected, *i. e.*, in the polish of the surface, produce different *degrees* of lustre.

The two principal kinds of lustre are the *metallic* and *non-metallic*. The metallic lustre is the lustre of all true metals, such as silver, copper, etc., and of most minerals in which metallic elements predominate. When the lustre is not distinctly or perfectly metallic, it is called *sub-metallic*. The *adamantine* lustre is intermediate between the metallic and non-metallic lustres. It is well shown in but few minerals, the diamond being the most perfect example.

Most of the minerals in which the non-metallic elements predominate have a *non-metallic* lustre. This is by far the most common lustre; only about one-fifth of the known minerals which have a distinct lustre being either metallic or adamantine. The non-metallic lustre embraces several varieties, which are named in the order of their importance:— The *vitreous* is the most common of all lustres. It is the lustre of glass, and of all minerals similar to glass in appearance, such as quartz, calcite, etc. The *resinous* lustre is seen in resins, of which the native mineral copalite is an example; it is also well exhibited in sulphur and sphalerite. The *pearly* lustre, *i. e.*, the lustre of pearl, is well shown only in minerals having a foliated or scaly structure, in other words, very perfect cleavage in one direction, such as talc, mica and gypsum. The *silky* or *satiny* lustre, like the pearly, is determined by the structure, being observed only in finely fibrous minerals. Fibrous gypsum or satin-spar is the best illustration, although fibrous calcite, serpentine, malachite, asbestus etc., are nearly as good. The *greasy* and *waxy* lustres are most common in certain amorphous minerals, such as serpentine.

The degrees of lustre are expressed as follows:—

The lustre is *splendent* when the surface reflects brilliantly, giving well defined images. It is *shining* when the reflected image is not well defined. When there is a general reflection from the surface, but no recognizable image, the lustre is *glistening*. If the reflection is very imperfect, and chiefly from minute points, the lustre is *glimmering*. A mineral is described as *dull*, when there is a complete absence of lustre, *i. e.*, when no light is regularly reflected, as in earthy minerals.

In using these tables, or any determinative system, it is a matter of the first importance to be able to recognize the different kinds of lustre, and especially to distinguish the two principal kinds, metallic and non-metallic. This is the first question to be answered with every species. One aid to answering it correctly is found in the perfect opacity of all metallic minerals. If the finest splinter, or the thinnest scale of the mineral in hand appears in the slightest degree translucent when held up to the light, it cannot be metallic. But the converse statement is not always true, since some non-metallic minerals will appear quite opaque, except in the excessively thin sections prepared with considerable labor for microscopic examination. Metallic minerals, again, never grind to an earthy (chalk-like) powder, but when carefully examined the powder sparkles, the mineral showing its metallic shine or glance in the smallest particles.

The darker colored and nearly opaque non-metallic minerals are among those most likely to be referred to the wrong lustre; and many of these, as well as the most of the sub-metallic, adamantine and dull species have, in consequence, been placed in both divisions of the tables.

Diaphaneity.—The light transmitted by minerals varies in amount within wide limits; or in other words, of the light received and not reflected, more or less may be *absorbed.* The following degrees of diaphaneity are usually recognized:—

Transparent, when the outline of an object seen through the mineral is perfectly distinct. *Subtransparent,* or *semitransparent,* when objects are seen but the outlines are not distinct. *Translucent,* when light is transmitted but objects are not seen. *Subtranslucent or semitranslucent,* when merely the edges of the specimen transmit light or are translucent. *Opaque,* when the mineral transmits no light in ordinary specimens.

The diaphaneity is of very little value in the determination of minerals, except as an aid in distinguishing the metallic and non-metallic lustres; for it is exceedingly variable and inconstant, the same species or even the same specimen often showing every degree from transparent to opaque. No other property of non-metallic minerals is affected in an equal degree by slight impurities and imperfections. In fact, if all mineral bodies were perfectly pure and homogeneous we should probably find that the metallic species are all opaque, and the non-metallic species are all transparent.

Color.—The color of a mineral is a measure of its power of absorbing different portions of the light that passes through it or falls on its surface. If no light is absorbed, or more correctly, if all the rays of the spectrum are absorbed equally, the color is white. If the red rays are absorbed the color is green, and so on. The color is always a mixture of the rays that are not absorbed.

The colors of metallic minerals are usually constant and afford great aid in distinguishing the species; and the same is true of a few of the non-metallic minerals. The great majority of the non-metallic species, however, would be white if perfectly pure; and since the actual colors depend upon the kind and quantity of impurity present they are extremely variable.

The different varieties of color in both metallic and non-metallic minerals are easily recognized; but a far more important distinction is that between *essential* and *non-essential* colors. By the essential color in any case is meant the color of the mineral itself in its purest state and in the finest particles. The non-essential colors, on the other hand, are chiefly the colors of the impurities contained in the minerals; although appearing in some cases to be due to the molecular structure. The essential color is known as the *streak*. Metallic minerals, which are always opaque, usually have essential colors. the color of the solid mineral and the powder being exactly or nearly the same. But non-metallic minerals, which are always somewhat diaphanous, usually have non-essential colors when not white, the color of the powder being white or gray, regardless of the color of the solid mineral. The explanation is this: In opaque minerals we can only see the impurity immediately on the surface, and this is, as a rule, not sufficient to affect the color. But in diaphanous minerals we look *into* the specimen, and see impurity below the surface; and thus bring into view, in many cases, sufficient impurity so that its color drowns that of the pure mineral. To prove this we have only to take any mineral (serpentine is a good example) having a non-essential color and make it opaque by pulverizing it or abrading its surface. The non-essential color, the color of the impurity, immediately disappears; just as water yellow with suspended clay becomes white when beaten into foam and thus made opaque. The essential color of a mineral, or the color of its powder, is called the *streak* of the mineral because the powder is most easily obtained by scratching the surface of the mineral and thereby pulverizing a minute portion of it. A still better method of observing the streak of all but adamantine minerals is to rub the specimen on an unpolished surface of white porcelain or Arkansas stone. The streak of very soft minerals is easily obtained by marking on paper, the lead-pencil mark being the streak of graphite. Very hard or adamantine minerals must be pulverized in a mortar.

Any merely superficial color, or color due to exposure to the air or weather, is called *tarnish*. A mineral is described as tarnished when the surface color is different from that on a fresh fracture. The tarnish is often irised or marked by various prismatic colors, which are explained as due to interference of light caused by a film cover-

ing the mineral. This superficial film or layer may be the result of oxidation or other alteration of the mineral itself, or it may be a thin incrustation of some foreign substance.

PROPERTIES RELATING TO HEAT AND MAGNETISM.—Under the head of heat, mineralogists investigate chiefly the *expansion* and *contraction* of minerals; their power of *absorbing*, *conducting* and *radiating* heat; and their *fusibility*.

Fusibility.—This is the most important of these properties and the only one that need be considered here. It is hardly practicable to determine with a thermometer the melting temperature of minerals, and the exact temperature of fusion is known for only a few species; but mineralogists are usually satisfied with knowing the relative fusing points of the different species. The relative fusibility is determined by comparison with six species which have been chosen as a *scale of fusibility*. These, beginning with the most readily fusible, are:—

1. Stibnite; 2. Natrolite; 3. Garnet; 4. Amphibole; 5. Orthoclase; 6. Bronzite; and we may add 7. Quartz. The fusibility of a mineral is determined by heating a fine splinter or fragment on charcoal, with the oxidizing blowpipe flame. If it fuses as readily as natrolite, it is 2, if, like quartz, it cannot be even rounded on the thinnest edges, it is 7, and so on.

Magnetism.—But few minerals are sensibly affected by an ordinary magnet; and these are the species containing the largest proportions of the strongly magnetic element—iron. The degree of magnetism is usually proportional to the percentage of iron, being greater in magnetite than in any other mineral except pure iron. Where the magnetism is weak it can only be detected by first pulverizing the mineral.

PROPERTIES RELATING TO THE ACTION ON THE SENSES.—These properties are of little importance, except with a few species.

Touch or Feel.—This is described as *meagre* (chalk, clay, etc.), *harsh*, *rough*, *smooth*, *unctuous* and *greasy*.

Taste.—A few minerals, being readily soluble, have a distinct taste. The principal kinds of taste recognized are the *astringent*, *cooling*, *sour*, *bitter*, *saline*, and *alkaline*.

Odor or Smell.—Solid minerals are usually devoid of odor unless subjected to some special treatment, as heating, rubbing, moistening, etc. The principal kinds of odor are the *sulphurous*, *arsenical*, *argillaceous*, and *fetid*.

CHEMICAL PROPERTIES.

What we have to consider here, chiefly, is the characteristic chemical behavior of the common minerals, and especially of their principal constituent elements. A systematic account of the composition and chemical relations of minerals would be out of place in a work

of this kind; but there is one general principle of such fundamental importance in determinative mineralogy as to demand the attention of the student at the very outset. This is *the relation of the composition to the physical properties of minerals*. The comparison of almost any mineral with the chemical elements of which it is composed shows that the properties of minerals are often very distinct from those of their constituent elements. Thus, the common mineral pyrite is composed of sulphur and iron, and in its general aspect it resembles neither of those elements; but a closer comparison shows that most of its properties may be observed in them; for it is yellow and brittle like sulphur, and metallic, hard and heavy like iron. Its specific gravity is almost an average of that of the two elements. In general, the contrast between minerals and their component elements is more strongly marked with the comparatively superficial properties, like color, than with the more fundamental properties, such as form, density, lustre, etc. The latter are, in a very large degree, the average of the properties of the elements. Thus, the minerals in which heavy metallic elements predominate, such as galenite, pyrite, hematite, etc., are themselves heavy and have usually a metallic lustre; while minerals composed chiefly of light, non-metallic elements, such as quartz, feldspar, gypsum, etc., are characterized by a low specific gravity and a non-metallic lustre. In accordance with this principle, we find that only those minerals are magnetic which are richest in iron, the magnetism increasing with the percentage of iron; and that, water being one of the lightest and softest of mineral-constituents, the hydrous species are invariably lighter and usually softer than anhydrous species of otherwise similar composition.

GENERAL BLOWPIPE AND CHEMICAL TESTS:—Certain standard or general tests recur so frequently in the tables that the student is recommended to acquire some familiarity with the *modus operandi* of each, and the general reactions which it yields, before proceeding to the more special tests for the identification of the particular constituents of minerals.

Heating in the Closed Tube.—The mineral should be in the form of powder or fine grains; and the bulk of a kernel of wheat will be sufficient in most cases. This is placed in the bottom of a hard glass tube three inches long and closed at one end. This end of the tube may be heated by directing the blowpipe flame against it, or more easily by holding it in the flame of the alcohol lamp or Bunsen gas burner. The heat is applied gently at first, and then more strongly if the reaction seems to demand it. The most essential feature of this test is that the mineral is heated nearly out of contact with the air; and the principal changes or reactions observable are (1) fusion, and (2) the formation of a sublimate in the upper part of the tube. Only minerals with low

fusing points can be melted under these conditions; and the only minerals yielding sublimates are those that are volatile or contain volatile constituents, such as sulphur, arsenic, mercury, water, etc.

Among the less important phenomena to be observed are the following: the mineral decrepitates; suffers a temporary or permanent change of color; or becomes magnetic.

Heating in the Open Tube.—The mineral, preferably in the form of one or several small grains, or of powder if it decrepitates, is placed in a tube of hard glass three inches long and open at both ends, the best position being three-fourths of an inch from one end, and this point is then heated in the same manner as the bottom of the closed tube, the tube being inclined as steeply as may be without having the mineral slide out. A current of air is thus caused to pass over the mineral while it is ignited, and the conditions are favorable for oxidation. The most important reactions are (1) the characteristic odors afforded by sulphides and arsenides, and (2) the sublimates formed in the upper part of the tube and consisting chiefly of the oxides of the same substances forming sublimates in the closed tube. Sulphurous and other acid vapors are given off which do not condense on the walls of the tube, but are recognized by the reddening of a slip of moistened blue litmus paper inserted at the upper end of the tube.

Heating on Charcoal.—The mineral, in about the same quantity as before, is placed in a shallow, saucer-shaped cavity excavated near one end of a suitable piece of charcoal. The charcoal is held so that the flame can be directed upon the mineral with the blowpipe. If the mineral decrepitates, or flies away, it may be finely pulverized and made into a paste with water, and then heated gradually until the mass coheres.

The principal phenomena to be observed are: (1) The odors of burning sulphur and arsenic, the latter resembling the odor of garlic. These are afforded by the elements and by sulphides and arsenides. (2) Fusion. (3) In the oxidizing flame, the metals are oxidized, and characteristic sublimates or coatings of the oxides are formed on the charcoal, which may be recognized by their color, extent and degree of volatility. (4) In the reducing flame several metals are readily reduced to the metallic state, especially if carbonate of soda is added to the pulverized minerals, and many compounds of iron become magnetic.

Heating in the Forceps.—If possible, a minute, slender fragment or splinter should be held by its larger end with a fine point projecting well beyond the end of the forceps, so that it may be introduced into the tip of the blue or oxidizing flame without heating the forceps. If the mineral decrepitates so that it can not be held in the

forceps, it may be finely pulverized, moistened with clean water, and supported on a loop of platinum wire.

The phenomena to be observed are: (1) The degree of fusibility of minerals. If the fine point melts into a round globule, it is readily fusible; if it is only slightly rounded on the end, it is difficultly fusible, and so on. For greater precision, the behavior of the mineral should be compared with that of similar splinters of the minerals forming the scale of fusibility. (2) The colors imparted to the flame by minerals. These are often very characteristic, and form a beautiful and delicate test for the following elements: All compounds of *soda* yield a bright *reddish yellow* flame. *Potash*, in most of its compounds, tinges the flame *bluish violet*. *Lithia* gives a *purplish red*, *lime* a *yellowish red*, and *strontia* a *pure red* color to the flame. *Baryta*, *copper*, *phosphoric acid* and *boric acid* give different shades of *green*. But the *chloride of copper* colors the flame *azure-blue*. (3) The colors imparted to the minerals themselves, when they are first moistened with a solution of nitrate of cobalt and then strongly heated. *Alumina compounds* become *blue*, *zinc oxide green* and *magnesia compounds flesh-red*.

Fusion with Borax and Salt of Phosphorus.—The tests with these reagents are most conveniently made on a short piece of platinum wire, one end of which is bent into a loop one-tenth of an inch in diameter. The loop is heated to redness and dipped into the pulverized flux; the portion which adheres to the wire is fused by the blowpipe flame; and this process is repeated until a full round bead of the fused flux is formed. The salt of phosphorous contains so much water of crystallization that it is very fluid when first fused; and until the water has evaporated the wire must be manipulated carefully to prevent the bead from falling off. When the bead is complete, and while it is still hot, it is touched to the powdered mineral, so that a small portion of the latter adheres. The bead is then strongly heated, usually with the oxidizing flame, until the mineral, if soluble, is completely dissolved in the bead. These tests are especially adapted to the detection of the various metallic oxides; and the chief phenomenon to be observed is the color imparted to the bead or glass by the oxide. For a complete account of the reactions afforded by these tests the student is referred to the more extended works on blowpipe analysis.

Alkaline Reaction.—A fragment of the mineral is strongly heated in the forceps or on charcoal, and then placed upon a strip of red litmus paper and moistened with a drop of water. If the color of the paper is changed to blue, the reaction is alkaline. This is a valuable test for the alkalies and alkaline earths.

Dissolving in Acid.—Chlorhydric (muriatic) acid answers in most

cases, nitric and sulphuric acids being rarely required. The acid should be used full strength, except when dilute acid is specially called for; and it is very important, especially with silicates, that the mineral to be tested should be in the form of an *impalpable powder*. The behavior of minerals with acids is most conveniently observed in the test tube. A small quantity of the *powdered* mineral is placed in the bottom of the tube, covered with one or two inches of acid, and heat applied gently until the acid boils.

LIST OF THE PRINCIPAL CONSTITUENTS OF MINERALS, WITH THE TESTS EMPLOYED IN THE TABLES FOR THE DETECTION OF EACH:—The substances are arranged alphabetically, for convenience of reference; and the student is expected to turn to this and the preceding section for full explantions of the tests indicated in the tables.

Alumina is recognized, in fusible minerals, by the beautiful blue color which they assume when strongly heated, and then moistened with cobalt solution and heated again. Very hard minerals must be finely pulverized.

Antimony and most of its compounds fuse and yield dense white fumes of antimony oxide when heated on charcoal. The oxide partially condenses on the coal, forming an extended white coating, which is volatile in the blowpipe flame.

Arsenic and nearly all of its compounds yield a sublimate of metallic arsenic in the closed tube, and a white crystalline sublimate of arsenious acid in the open tube. On charcoal, this element is recognized by the abundant gray smoke, the strong garlic odor, and the extremely volatile gray coating which it forms on the coal.

Baryta is recognized by the yellowish green color imparted to the blowpipe flame by all of its compounds except silicates.

Bismuth fuses, volatilizes and oxidizes on charcoal, forming a yellow, volatile coating.

Boracic Acid colors the blowpipe flame an intense yellowish green. This test is more reliable if the mineral is moistened with sulphuric acid before heating.

Carbonic Acid is readily set free in the gaseous form, from all carbonates, by chlorhydric acid, especially if the mineral be pulverized or the acid heated. The effervescence of the escaping carbonic acid is distinguished from that due to sulphuretted hydrogen by the offensive odor of the latter gas.

Chlorine is most conveniently detected by adding the mineral to a salt of phosphorus bead which has been saturated with copper oxide, and observing the intense blue color which is imparted to the blowpipe flame.

Chromium is recognized by the emerald-green color which its oxide imparts to the borax bead.

Copper and its compounds impart a green color to the flame and

to the borax and salt of phosphorous beads. In most cases the flame coloration will be blue if the mineral be first moistened with chlorhydric acid. Copper can be reduced from nearly all of its ores by fusion with soda on charcoal.

Fluorine is recognized in most of its compounds by heating the mineral in the closed tube with potassium bisulphate and pulverized glass. Fluorhydric acid is set free, which etches the glass in the bottom of the tube, and a white sublimate of silicon fluoride is formed in the upper part of the tube.

Iron may be recognized by the yellow and brown colors which its oxides impart to the borax bead; and by the fact that nearly all the compounds of iron become magnetic when heated, especially if heated on charcoal with soda.

Lead is reduced to the metallic state with soda, and forms a volatile yellow coating of lead oxide on the charcoal.

Lime colors the blowpipe flame yellowish red; and many compounds of lime give an alkaline reaction after heating.

Lithia, in most of its compounds, colors the flame bright purplish red.

Magnesia is recognized in many of its compounds by the pink color which they assume when moistened with cobalt solution and strongly heated.

Manganese is recognized in all of its compounds by the highly characteristic colors which it imparts to the fluxes, With borax it forms a clear bead of a deep amethystine red or violet-red color; while fusion with soda (or if necessary, with soda and nitre) yields an opaque, bright green mass.

Mercury always yields a sublimate of metallic mercury when any of its compounds are heated in the closed tube with soda. This sublimate consists of minute, liquid drops.

Nickel is most readily recognized by the red bead which it forms with borax. It is also easily reduced to a magnetic mass on charcoal.

Phosphoric Acid may usually be recognized by the green color which phosphates impart to the flame, especially if previously moistened with sulphuric acid. Or the pulverized mineral may be fused in the closed tube with a bit of magnesium wire, and a drop of water added to the fused mass when cold, evolving phosphuretted hydrogen, which is recognized by its disagreeable odor.

Potassa may be often recognized by the violet color which it imparts to the flame.

Silica effervesces with soda on platinum wire, forming a clear glass if the soda be not in excess. Most of the silicates are decomposed by salt of phosphorus, leaving a cloudy skeleton of silica floating in the bead. Many hydrous and basic silicates are decomposed by chlorhydric acid, leaving the silica in the form of a stiff jelly, or a floculent powder.

Silver is easily reduced with soda on charcoal, and forms a brown coating of silver oxide.

Soda is easily recognized by the intense yellow color which it imparts to the flame.

Strontia is known by its crimson flame. The color is more intense when the mineral is moistened with chlorhydric acid.

Sulphur, as it occurs in sulphides, may be recognized in several ways. Bisulphides, or those containing the largest proportion of sulphur, yield sublimates of sulphur in the closed tube. All sulphides redden moistened blue litmus paper in the open tube. If any sulphide is fused with soda in the closed tube and the fused mass transferred to a bright silver coin and moistened with water, a dark brown stain of silver sulphide is left on the coin. This test will also prove the presence of sulphur in any *sulphate* if a little pulverized charcoal is added to the mixture in the closed tube before fusion, or the fusion is made on charcoal. All sulphides effervesce with hot chlorhydric acid, evolving sulphuretted hydrogen, which is recognized by its odor.

Tin is reduced to the metallic state with soda on charcoal.

Water may be expelled from nearly all hydrous minerals by heating in the closed tube, the vapor or steam condensing in the upper part of the tube and wetting the glass.

Zinc is reduced with soda on charcoal, but the metal immediately oxidizes, forming a coating on the coal which is yellow when hot and white when cold. The white and gray compounds of zinc assume a green color when moistened with cobalt solution and strongly ignited.

List of Apparatus and Reagents.

Blowpipe. The simple and inexpensive brass blowpipe used by jewellers answers very well for all the tests described in these tables; although the chemical blowpipe, with a platinum jet, a mouth-piece and a chamber for condensing the moisture of the breath, is, of course, rather more satisfactory in operation and more durable.

Fuel and Lamp. The most satisfactory source of heat for blowpipe and chemeial experiments is the Bunsen gas-burner; the aperture for the admission of air at the bottom of the burner being closed by a sliding tube when the blowpipe is used, and left open when it is desired to use the direct heat of the flame. When gas is not available, a small alcohol lamp is recommended as most generally useful; although for use with the blowpipe alone a common oil lamp (olive oil is best) or stearine candle will answer in most cases. The blowpipe enables us to control not only the direction but the quality of the flame. The *reducing flame* (R. F.) is produced by holding the jet of the blowpipe outside of the flame and deflecting the entire flame by a gentle blast without essentially changing its character. The reducing flame should be used whenever it is desired to reduce to the

metallic state, or partially deoxidize, metallic oxides. The oxidizing flame (O. F.) is obtained by introducing the jet into the flame and blowing more strongly, the deflected flame forming a slender blue cone. This is the flame usually employed, especially for oxidizing or roasting minerals, forming coatings on charcoal, and whenever a high temperature is desired, as in testing the fusibility and flame-coloration of minerals.

Forceps. Common steel forceps about four inches long will answer in most cases; although platinum-pointed forceps are very much better, if not essential, in testing fusibility and flame-coloration.

Platinum Wire. A piece about three inches long of moderately stout wire is the best. Before using, a circular loop one-tenth of an inch in diameter should be formed on the end of it.

Glass Tubes. These should be of hard glass one-eighth to one-fourth inch in diameter, and three to four inches long. The *open* tubes are open at both ends and are formed by simply cutting the tubing with a file into pieces of the proper length. The closed tubes are closed at one end, and are formed by heating pieces seven or eight inches long in the middle until the glass is soft enough to be drawn apart.

Charcoal. This important support should be made from soft wood and thoroughly burned, so as not to crack or snap when heated. Rectangular pieces four to eight inches long and two inches wide are the most convenient.

Agate Mortar. This instrument is very useful in reducing minerals to a fine powder, especially for treatment with acid; but it is unfortunately somewhat expensive.

Hammer, Anvil and Ring. These are employed to break and pulverize fragments of minerals, and answer in most cases as a substitute for the agate mortar.

File. A small three-cornered file is useful for testing the hardness and streak of minerals, and for cutting glass tubing. A notch is made with the file in one side of the tube, which is then gently bent and pulled apart, the nails of the two thumbs being brought together opposite the notch.

Magnet. A small steel magnet aids in the recognition of magnetic minerals.

Lens. A common pocket lens or magnifying glass is useful in many ways.

Test-tubes. Small test-tubes of hard glass are needed for treating minerals with acids.

Soda (Carbonate of Soda).

Salt of Phosphorus (Phosphate of Soda and Ammonia).

Borax (Biborate of Soda).

Oxide of Copper.

Cobalt Solution (Nitrate of Cobalt).
Chlorhydric Acid.
Sulphuric Acid.
Nitric Acid.
Litmus Paper. The blue paper may be reddened by moistening it and holding it over the open mouth of the acid bottle.

SYNOPSIS OF THE CLASSIFICATION OF MINERALS.

SUBKINGDOM OF ELEMENTS.

Class of Metals.

1. *Gold Group.*—Gold, silver.
2. *Iron Group.*—Copper, iron, mercury.

Class of Metalloids.

3. *Arsenic Group.*—Bismuth, antimony, arsenic.
4. *Sulphur Group.*—Sulphur.
5. *Carbon-Silicon Group.*—Diamond, graphite.

SUBKINGDOM OF BINARY COMPOUNDS.

Class of Sulphides, Sulpharsenides, Arsenides etc.

GOLD, IRON AND TIN SUBCLASS.

Proto or Galena Group.

6. *Galena Family.*—Galenite, bornite.
7. *Blende Family.*—Sphalerite.
8. *Pyrrhotite Family.*—Cinnabar, millerite, pyrrhotite,
9. *Chalcocite Family.*—Chalcocite. [niccolite.

Deuto or Pyrite Group.

10. *Pyrite Family.*—Pyrite, chalcopyrite, smaltite, cobaltite.
11. *Marcasite Family.*—Marcasite, arsenopyrite.

ARSENIC AND SULPHUR SUBCLASS.

12. *Realgar Family.*—Realgar.
13. *Orpiment Family.*—Orpiment, stibnite.
14. *Molybdenite Family.*—Molybdenite.

SULPHARSENITES, SULPHANTIMONITES, ETC.

15. Stephanite, tetrahedrite, pyrargyrite, proustite.

Class of Chlorides, Bromides and Iodides.

GOLD, IRON AND TIN SUBCLASS.

Anhydrous Division.

16. *Halite Family.*—Halite, cerargyrite.

Oxychloride Division

17. *Atacamite Family.*—Atacamite.

Class of Fluorides.

GOLD, IRON AND TIN SUBCLASS.

Anhydrous Division.

18. *Fluorite Family.*—Fluorite.
19. *Cryolite Family.*—Cryolite.

Class of Oxides.

GOLD, IRON AND TIN SUBCLASS.

Anhydrous Division.

Protoxide Group.

20. *Cuprite Family.*—Cuprite.
21. *Zincite Family.*—Water, zincite.
22. *Melaconite Family.*—Melaconite.

Protoxide and Sesquioxide Group.

23. *Spinel Family.*—Spinel, magnetite, franklinite, chromite.
24. *Chrysoberyl Family.*—Chrysoberyl.

Sesquioxide Group.

25. *Corundum Family.*—Hematite, menaccanite, corundum,

Deutoxide Group. [perofskite.

26. *Rutile Family.*—Cassiterite, rutile, zircon.
27. *Brookite Family.*—Brookite, pyrolusite.

Hydrous Division.

28. *Turgite Family.*—Turgite.
29. *Diaspore Family.*—Diaspore, göthite, manganite.
30. *Limonite Family.*—Limonite.
31. *Brucite Family.*—Brucite, gibbsite.
32. *Psilomelane Family.*—Psilomelane, wad.

CARBON-SILICON SUBCLASS.

33. *Anhydrous Divison.*—Quartz.
34. *Hydrous Division.*—Opal.

SUBKINGDOM OF TERNARY COMPOUNDS.

Class of Tantalates and Columbates.

35. *Tantalite Family.*—Tantalite, columbite, samarskite.

Class of Phosphates, Arsenates, etc.

Anhydrous Division.

36. *Apatite Family.*—Apatite, pyromorphite, mimetite,

Hydrous Division. [vanadinite.

37. *Vivianite Family.*—Vivianite, erythrite.
38. *Wavellite Family.*—Lazulite, wavellite, turquois, autunite.

Class of Borates.

39. *Sassolite Family.*—Sassolite.
40. *Borax Family.*—Borax, ulexite.

Class of Tungstates, Molybdates and Chromates.

41. *Wolframite Family.*—Wolframite, wulfenite, scheelite.

Class of Sulphates.

Anhydrous Division.

42. *Celestite Family.*—Barite, celestite, anhydrite, anglesite.

Hydrous Division.

43. *Gypsum Family.*—Gypsum.

Class of Carbonates.

Anhydrous Division.

44. *Calcite Family.*—Calcite, dolomite, magnesite, siderite, rhodochrosite, smithsonite.
45. *Aragonite Family.*—Aragonite, witherite, strontianite,

Hydrous Division. [cerussite.

46. *Malachite Family.*—Malachite, azurite.

Class of Silicates.

Anhydrous Division.

Bisilicate Group.

47. *Pyroxene Family.*—Enstatite, hypersthene, wollastonite, pyroxene.
48. *Spodumene Family.*—Spodumene, rhodonite.
49. *Amphibole Family.*—Amphibole.
50. *Beryl Family.*—Beryl.

Unisilicate Group.

51. *Phenacite Family.*—Willemite.

52. *Chrysolite Family.*—Chrysolite.
53. *Garnet Family.*—Garnet.
54. *Vesuvianite Family.*—Vesuvianite.
55. *Epidote Family.*—Epidote, allanite, zoisite.
56. *Mica Family.*—Muscovite, biotite, phlogopite, lepidomelane, lepidolite.
57. *Leucite Family.*—Sodalite, leucite, lapis-lazuli.
58. *Scapolite Family.*—Wernerite.
59. *Nephelite Family.*—Nephelite, cancrinite.
60. *Feldspar Family.*—Orthoclase, albite,oligoc lase, labradorite, anorthite.

Subsilicate Group.

61. *Chondrodite Family.*—Chondrodite.
62. *Tourmaline Family.*—Tourmaline.
63. *Andalusite Family.*—Andalusite, fibrolite, cyanite.
64. *Euclase Family.*—Datolite, topaz.
65. *Titanite Family.*—Titanite.
66. *Staurolite Family.*—Staurolite.

Hydrous Division.

General Subdivision.

67. *Pectolite Family.*—Pectolite, laumontite.
68. *Chrysocolla Family.*—Chrysocolla.
69. *Calamine Family.*—Calamine, prehnite.
70. *Apophyllite Family.*—Apophyllite.

Zeolite Subdivision.

71. *Mesotype Family.*—Thomsonite, natrolite.
72. *Analcite Family.*—Analcite.
73. *Chabazite Family.*—Chabazite, gmelinite.
74. *Stilbite Family.*—Stilbite, heulandite.

Margarophyllite Subdivision.

75. *Talc Family.*—Talc, pyrophyllite.
76. *Sepiolite Family.*—Sepiolite, glauconite.
77. *Serpentine Family.*—Serpentine, deweylite.
78. *Kaolinite Family.*—Kaolinite.
79. *Pinite Family.*—Pinite.
80. *Hydro-mica Family.*—Hydromica.
81. *Chlorite Family.*—Ripidolite, prochlorite.
82. *Chloritoid Family.*—Margarite, chloritoid.

Hydrocarbons.

83. *Simple Hydrocarbons.*—Petroleum, etc.
84. *Oxygenated Hydrocarbons.*—Amber, copal, coal, etc.

To aid students in referring new minerals to their proper places in the classification, and thus determining their relations to the other species, the name of each species in the tables is accompanied by the number of the family to which it belongs.

GENERAL CLASSIFICATION.

A. METALLIC LUSTRE.

I. Color red or brown. Page

1. Very soft 26
2. Soft 26
3. Hard 26
4. Very hard 28

II. Color yellow.

1. Very soft 28
2. Soft 28
3. Hard 30
4. Very hard 30

III. Color black.

1. Very soft 30
2. Soft 32
3. Hard 32
4. Very hard 36

IV. Color gray.

1. Very soft 36
2. Soft 38
3. Hard 38
4. Very hard 38

V. Color white.

1. Very soft 40
2. Soft 40
3. Hard 40
4. Very hard 40

B. NON-METALLIC LUSTRE.

I. Streak red or brown. Page

1. Very soft 42
2. Soft 42
3. Hard 42
4. Very hard 44

II. Streak yellow.

1. Very soft 46
2. Soft 46
3. Hard 46
4. Very hard 46

III. Streak black.

1. Very soft 48
2. Soft 48
3. Hard 48
4. Very hard 48

IV. Streak green or blue.

1. Very soft 50
2. Soft 50
3. Hard 50
4. Very hard 50

V. Streak white or gray.

1. Very soft 52
2. Soft 54
3. Hard 60
4. Very hard 64
5. Adamantine 70

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
I. Color Red or Brown.	1. Very Soft.	G. 1.25.	**Brown Coal** (84).	C,H,O, etc.	Resinous to dull.	Brown to black.	Brown.
		G. 3—6.	**Realgar** (12).	AsS.	Resinous.	Aurora-red	Aurora-red.
			Proustite (15).	Ag_3AsS.	Adamantine.	Cochineal-red.	Cochineal-red.
			Pyrargyrite (15).	Ag_3SbS.	Adamantine.	Black to cochineal-red.	Cochineal-red.
		G. 9.	**Cinnabar** (8). Compare *Red Ochre*	HgS.	Adamantine.	Cochineal-red.	Scarlet.
	2. Soft.	Streak red. Malleable.	**Copper** (2).	Cu.	Metallic.	Copper-red.	Copper-red.
		Streak red, yellow or brown. Brittle.	**Cuprite** (20).	Cu_2O.	Adamantine to dull.	Red to brown.	Red to brown.
			Zincite (21).	ZnO.	Sub-adamantine.	Red and orange.	Orange.
			Sphalerite (7).	ZnS.	Resinous.	Brown.	Brown to yellow.
		Streak grayish black.	**Pyrrhotite** (8).	Fe_7S_8.	Metallic.	Bronze.	Dark grayish black.
			Bornite (6).	(FeCu)S.	Metallic.	Dark copper-red.	Pale grayish black.
	3. Hard.	Streak black.	**Niccolite** (8).	NiAs.	Metallic.	Pale copper-red.	Brownish black.
			Pyrrhotite (8).	Fe_7S_8.	Metallic.	Bronze.	Grayish black.
		Streak brown, yellow or red.	**Sphalerite** (7).	ZnS.	Resinous.	Brown.	Brown to yellow.
			Göthite (29).	$Fe_2O_3 + H_2O$.	Adamantine to dull.	Brown.	Ochre-yellow.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
1.	Brittle to sectile.	1.25	Compact or laminated.	None.	Opaque.	Readily ignited, burning with flame.
2.	Brittle.	3.5	V. Also massive.	Clinopinacoidal and basal.	Transparent to translucent.	Volatile and combustible, burning with a blue flame and arsenical odor.
2.25	Brittle.	5.5	III. Also massive.	Conchoidal.	Translucent.	Gives reactions for arsenic and silver.
2.25	Brittle.	5.8	III. Also massive.	Conchoidal.	Translucent.	Gives reactions for antimony and silver.
2.25	Brittle to sectile.	9.	III. Usually massive.	Subconchoidal.	Usually opaque.	Volatile; with soda in closed tube yields sublimate of mercury.
2.75	Malleable.	8.8	I. Also massive and arborescent.	None.	Opaque.	Fuses readily; green solution with nitric acid, which becomes blue with ammonia.
3.5	Brittle.	6.	I Also capillary and massive.	Octahedral.	Usually impure and opaque.	Colors flame green and fuses readily, yielding metallic copper.
4.	Brittle.	5.5	III. Also massive.	Basal, perfect.	Usually opaque.	Infusible; soluble in acids; with soda on ch. gives a zinc coating.
3.5	Brittle.	4.	I. Also massive.	Dodecahedral, perfect.	Translucent to opaque.	Like zincite, but gives reactions for sulphur, and dissolves with effervescence (H_2S).
3.5	Brittle.	4.5	III. Usually massive.	Uneven.	Opaque.	Fusible to a black, magnetic mass; usually slightly magnetic before fusion.
3.	Brittle.	5.	I. Usually massive.	Octahedral, in traces.	Opaque. Blue and green tarnish.	Gives reactions for copper, and fuses to a black, magnetic globule.
5.25	Brittle.	7.5	III. Usually massive.	Uneven.	Opaque.	On ch., gives arsenical fumes and a magnetic globule.
4.5	Brittle.	7.5	III. Usually massive.	Uneven.	Opaque.	Fusible to a black, magnetic mass; usually slightly magnetic before fusion.
4.	Brittle.	4.	I. Usually massive.	Dodecahedral, perfect.	Translucent to opaque.	Reactions for sulphur and dissolves in acid with effervescence (H_2S).
5.25	Brittle.	4.2	IV. Usually massive, fibrous or botryoidal.	Prismatic, perfect.	Opaque.	Yields water in closed tube; magnetic on charcoal.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
I. Color Red or Brown.—Continued.	3. Hard.—Continued.	Streak brown, yellow or red—contin.	**Limonite** (30).	$2Fe_2O_3 + 3H_2O$.	Submetallic to silky.	Brown.	Ochre-yel-lo
			Turgite (28).	$2Fe_2O_3 + H_2O$.	Submetallic to silky.	Reddish black to red.	Red.
			Zincite (21).	ZnO.	Sub-ada-mantine.	Red and orange.	Orange.
			Cuprite (20).	Cu_2O.	Submetallic to adaman-tine.	Red to brown.	Red to brow
	4. Very Hard.	G. nearly 7.	**Cassiterite** (26).	SnO_2.	Adamantine.	Brown.	Gray to brow
		G. 4.2	**Rutile** (26).	TiO_2.	Adamantine to metallic.	Brown.	Gray to yellowis
			Brookite (27).	TiO_2.	Adamantine to metallic.	Brown.	Pale brow
II. Color Yellow.	1. Very Soft.	G. 19.3 Malleable.	**Gold** (1).	Au.	Metallic.	Gold-yellow.	Yellow.
		G. 3.5 Brittle.	**Orpiment** (13).	As_2S_3.	Pearly to resinous.	Lemon-yellow.	Yellow.
	2. Soft.	Streak yellow. Malleable.	**Gold** (1).	Au.	Metallic.	Gold-yellow.	Yellow.
		Streak yellow. Brittle.	**Millerite** (8).	NiS.	Metallic.	Brass-yellow.	Bright yello
			Sphalerite (7).	ZnS.	Resinous.	Brown to yellow.	Dull yello
		Streak black or nearly so.	**Chalcopyrite** (10).	$(CuFe)S_2$.	Metallic.	Brass-yellow.	Greenish blacl
			Pyrrhotite (8).	Fe_7S_8.	Metallic.	Bronze.	Grayish blacl
			Bornite (6).	(CuFe)S.	Metallic.	Brownish copper.	Grayish blac

ıacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
le.	4.	Massive, botryoidal, fibrous, etc.	Uneven, splintery, etc.	Opaque.	Yields water in closed tube; magnetic on charcoal.
le.	3.7	Massive, botryoidal, fibrous, etc.	Uneven, splintery, etc.	Opaque.	Like limonite.
le.	5.5	III. Also granular.	Basal, perfect.	Opaque.	Infusible; soluble in acids; with soda on charcoal gives zinc coating.
le.	6.	I. Also capillary and massive.	Octahedral.	Usually impure and opaque.	Colors flame green and fuses readily, yielding metallic copper.
le.	6.8	II. Also massive, botryoidal, etc.	Prismatic, indistinct.	Nearly opaque.	Infusible and insoluble; with soda on charcoal reduced to metallic tin.
le.	4.2	II. Also massive.	Prismatic, distinct.	Nearly opaque.	Infusible and insoluble; reactions for titanium.
le.	4.2	IV. Small square crystals.	Prismatic, indistinct.	Translucent to opaque.	Like rutile.
eable.	19.3	I. Usually in grains or nuggets	None.	Translucent.	Readily fusible; insoluble in common acids; does not tarnish.
le to brittle.	3.5	IV. Foliated and massive.	Macropinacoidal very perfect.	Opaque.	Volatilizes and gives reactions for arsenic and sulphur.
eable.	19.3	I. Usually in grains or nuggets	None.	Opaque.	Readily fusible; insoluble in common acids; does not tarnish.
le.	5.	III. Acicular or columnar.	Rhombohedral.	Opaque.	Reactions for sulphur; fuses on charcoal to a magnetic globule.
le.	4.	I. Usually massive	Dodecahedral, perfect.	Translucent to opaque.	Reactions for sulphur; with soda on charcoal gives a zinc coating.
le.	4.2	II. Usually massive.	Uneven.	Opaque. Iridescent tarnish.	Sulphur in closed tube; magnetic globule on charcoal; green solution with nitric acid.
le.	4.5	III. Usually massive.	Uneven.	Opaque.	Fusible to magnetic mass: usually slightly magnetic before fusion.
le.	5.	I. Usually massive.	Uneven.	Opaque, blue and green tarnish.	Reactions for copper; fuses to magnetic globule.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
II. Color Yellow.—Continued.	3. Hard.	Streak nearly black. H. about 4.	**Chalcopyrite** (10).	$(CuFe)S_2$.	Metallic.	Brass-yellow.	Greenish black.
			Pyrrhotite (8).	Fe_7S_8.	Metallic.	Bronze.	Grayish black.
		Streak nearly black. H. about 6.	**Marcasite** (11).	FeS_2.	Metallic.	Grayish yellow.	Grayish black.
			Pyrite (10).	FeS_2.	Metallic.	Pale brass-yellow.	Greenish black.
		Streak yellow. Crystalline or granular.	**Sphalerite** (7).	ZnS.	Resinous.	Brown to yellow.	Dull yellow.
		Streak yellow. Compact or fibrous.	**Limonite** (30).	$2Fe_2O_3+3H_2O$.	Submetallic to silky.	Brown to yellow.	Yellow.
			Göthite (29).	$Fe_2O_3+H_2O$.	Imperfect adamantine.	Brown to yellow.	Yellow.
	4. Very Hard.	Grayish yellow.	**Marcasite** (11).	FeS_2.	Metallic.	Grayish yellow.	Grayish black.
		Pale brass-yellow.	**Pyrite** (10).	FeS_2.	Metallic.	Pale brass-yellow.	Greenish black.
III. Color Black.	1. Very Soft.	Streak gray. Foliated.	**Molybdenite** (14).	MoS2.	Metallic.	Lead-gray.	Lead-gray.
		Streak black. G. about 2.	**Graphite** (5).	C.	Metallic.	Black.	Black.
		Streak black. G. 4 to 6.	**Wad** (32).	$2MnO_2+H_2O$.	Dull.	Black.	Black.
			Pyrolusite (27).	MnO_2.	Metallic.	Black.	Black.
			Stephanite (15).	Ag_5SbS_3.	Metallic.	Black.	Black.
			Pyrargyrite (15).	Ag_3SbS_3.	Adamantine.	Black to cochineal-red.	Cochineal Red.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
4.	Brittle.	4.2	II. Usually massive.	Uneven.	Opaque. Iridescent tarnish.	Sulphur in closed tube; magnetic globule on ch.; green sol. in nitric acid.
4.5	Brittle.	4.5	III. Usually massive.	Uneven.	Opaque.	Fusible to magnetic mass; usually slightly magnetic before fusion.
6.	Brittle.	4.7	IV. Often massive or globular.	Prismatic.	Opaque. Decomposes readily.	Sulphur in closed tube; magnetic residue on charcoal.
6.	Brittle.	5.	I. Cubes and pyritohedrons; often massive.	Uneven.	Opaque.	Like marcasite.
4.	Brittle.	4.	I. Usually massive.	Dodecahedral, perfect.	Translucent to opaque.	Reactions for sulphur; with soda on ch. gives a zinc coating.
5.25	Brittle.	4.	Massive, botryoidal, fibrous, etc.	Uneven, splintery, etc.	Opaque.	Yields water in closed tube; magnetic on charcoal.
5.25	Brittle.	4.2	IV. Usually massive, fibrous or botryoidal.	Prismatic, perfect.	Opaque.	Yields water in closed tube; magnetic on charcoal.
6.5	Brittle.	4.7	IV. Often massive or globular.	Prismatic.	Opaque. Decomposes readily.	Sulphur in closed tube; magnetic residue on charcoal.
6.5	Brittle.	5.	I. Cubes and pyritohedrons; often massive.	Uneven.	Opaque.	Sulphur in closed tube; magnetic residue on charcoal.
1.25	Sectile.	4.6	III. Usually foliated.	Basal, perfect.	Opaque. Greasy feel.	Infusible; reactions for sulphur.
1.25	Sectile.	2.2	III. Usually foliated.	Basal, perfect.	Opaque. Greasy feel.	Infusible; unaltered by acids.
1.	Earthy.	3.8	Amorphous.	Earthy.	Opaque.	Yields water in closed tube; amethystine bead with borax; evolves chlorine with HCl.
2.	Brittle.	4.8	IV. Usually columnar or massive.	Prismatic.	Opaque.	Infusible; amethystine bead with borax; evolves chlorine with HCl.
2.	Brittle.	6.25	IV. Usually massive.	Imperfect.	Opaque.	On ch. gives coating of antimony oxide and globule of silver.
2.25	Brittle.	5.8	III. Also massive.	Conchoidal.	Translucent.	Gives reactions for antimony and silver.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
III. Color Black.—Continued.	2. Soft.	Streak black. G. 1 to 2.	**Mineral Coal** (84).	C,H,O, etc.	Submetallic.	Black.	Black.
			Manganite (29).	$Mn_2O_3+H_2O$.	Submetallic.	Dark gray to black.	Brown to black.
			Pyrolusite (27).	MnO_2.	Metallic.	Black.	Black.
		Streak black or nearly so. G. 4 to 6.	**Chalcocite** (9).	CuS.	Metallic.	Dark lead-gray.	Dark lead-gray.
			Melaconite (22).	CuO.	Metallic to dull.	Black.	Black.
			Tetrahedrite (15).	$Cu_8Sb_2S_7$.	Metallic.	Dark gray to black.	Dark gray to black.
			Stephanite (15).	Ag_5SbS.	Metallic.	Black.	Black.
		Streak not black. Not micaceous.	**Sphalerite** (7).	ZnS.	Submetallic.	Black.	Brown.
		Streak not black. Micaceous.	**Phlogopite** (56).	$(KMgAl)_2SiO_4$.	Pearly to submetallic.	Dark brown to black.	Gray.
			Biotite (56).	$(KFeMgAl)_2SiO_4$.	Pearly to submetallic.	Black.	Gray.
			Lepidomelane (56).	$(KFeAl)_2SiO_4$.	Adamantine to pearly.	Black.	Grayish green.
	3. Hard.	Strongly magnetic; malleable.	**Iron** (2).	Fe.	Metallic.	Iron-gray to black.	Iron-gray to black.
		Strongly magnetic. Brittle.	**Magnetite** (23).	Fe_3O_4.	Metallic.	Iron-black.	Black.
		Streak black. G. above 7.	**Wolframite** (41).	$(FeMn)WO_4$.	Submetallic.	Brownish black.	Brownish black.
		Streak black. Antimony coating on charcoal.	**Tetrahedrite** (15).	$Cu_8Sb_2S_7$.	Metallic.	Black.	Black.

nacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
tle.	1.5	Compact to laminated.	Even to conchoidal.	Opaque.	Burns before blowpipe; infusible and insoluble in acids.
tle.	4.3	IV. Usually acicular or columnar.	Prismatic, perfect.	Opaque.	Yields water in closed tube; amethystine bead with borax.
tle.	4.8	IV. Usually columnar or massive.	Prismatic.	Opaque.	Infusible; amethystine bead with borax; evolves chlorine with HCl.
tle.	5.7	IV. Often massive.	Prismatic.	Opaque.	Fusible; blue flame with HCl; with soda on charcoal yields copper; sulphur reaction.
tle to earthy.	6.25	IV. Usually massive or earthy.	Uneven or earthy.	Opaque.	Infusible; copper with soda on charcoal; green solution with nitric acid.
tle.	4.8	I. Usually massive.	Uneven.	Opaque.	On charcoal gives coating of antimony oxide; with soda yields copper.
tle.	6.25	IV. Usually massive.	Imperfect.	Opaque.	On charcoal gives coating of antimony oxide; with soda gives silver.
tle.	4.	I. Usually massive.	Dodecahedral, perfect.	Opaque.	Reactions for sulphur; with soda on charcoal gives zinc coating.
stic and sectile.	2.8	IV. Foliated.	Basal, perfect.	Opaque to transparent.	Infusible; decomposed by strong sulphuric acid.
stic and sectile.	2.9	III. Foliated.	Basal, perfect.	Opaque to transparent. Green or brown by trans. light.	Like phlogopite.
tile to brittle.	3.	III. Foliated.	Basal, perfect.	Opaque to translucent.	Fuses to magnetic globule; decomposed by sulphuric acid.
lleable.	7.5	I. Usually compact.	Octahedral; usually none.	Opaque. Strongly magnetic.	Infusible; soluble in HCl.
ttle.	5.	I. Usually granular.	Octahedral.	Opaque. Strongly magnetic.	Infusible; soluble in HCl.
ttle.	7.4	V. Also lamellar or massive.	Prismatic, perfect.	Opaque.	Fuses easily to a magnetic gobule; reactions for manganese and tungsten.
ittle.	4.8	I. Usually massive.	Uneven.	Opaque.	On charcoal gives antimony coating; with soda gives copper.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
III. Color Black.—Continued.	3. Hard.—(Continued.	Streak black. Never crystalline.	**Psilomelane** (32).	MnO_2 $+H_2O$.	Submetallic.	Iron-black.	Brownish black.
		Streak black. Always crystalline.	**Menaccanite** (25).	$(FeTi)O_3$.	Metallic.	Black.	Brownish black.
			Manganite (29).	Mn_2O_3 $+H_2O$.	Metallic.	Black.	Brownish black.
			Columbite (35).	$FeCb_2O_6$.	Submetallic.	Black.	Brownish black.
		Streak dark gray	**Brookite** (27).	TiO_2.	Metallic to adamantine.	Black.	Dark gray.
			Allanite (55).	Complex silicate.	Submetallic.	Black.	Dark gray.
		Streak brown. H. 4.	**Sphalerite** (7).	ZnS.	Resinous to adamantine.	Black.	Brown.
		Streak brown. H. 5-5	**Chromite** (23).	$FeCr_2O_4$.	Submetallic.	Black.	Grayish brown.
			Franklinite (23).	$FeZnMnO_4$.	Metallic.	Iron-black.	Reddish brown.
			Samarskite (35).	Complex columbate.	Submetallic, shining.	Black.	Reddish brown.
		Streak red.	**Hematite** (25).	Fe_2O_3.	Metallic to dull.	Black.	Red.
			Turgite (28).	$2Fe_2O_3$ $+H_2O$.	Submetallic.	Reddish black.	Red.
		Streak yellow.	**Göthite** (29).	Fe_2O_3 $+H_2O$.	Adamantine, imperfect.	Brownish black.	Yellow.
			Limonite (30).	$2Fe_2O_3$ $3H_2O$.	Submetallic to silky.	Brown to black.	Yellow.
		Distinctly isometric.	**Perofskite** (25).	$(CaTi)O_3$.	Metallic to adamantine.	Black to brown, yellow, etc.	White to gray

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5.	Brittle.	4.2	Compact and often botryoidal.	Even or conchoidal.	Opaque.	Infusible; water in closed tube; evolves chlorine with HCl.
5.	Brittle.	4.75	III. Often laminated.	None.	Opaque. Often slightly magnetic.	Infusible; reaction for titanium.
4.	Brittle.	4.3	IV. Usually prismatic or columnar.	Prismatic, perfect.	Opaque. Never magnetic.	Infusible; yields water in closed tube; amethystine bead with borax.
6.	Brittle.	6.	IV. Crystals to coarsely massive.	Prismatic.	Opaque.	Infusible.
5.5	Brittle.	4.2	IV. Square. crystals.	Prismatic, indistinct.	Opaque.	Infusible; reactions for titanium.
5.5	Brittle.	3.6	V. Tabular and prismatic.	In traces.	Opaque.	Fuses with intumescence to a magnetic globule; gelatinizes with HCl.
4.	Brittle.	4.	I. Usually massive.	Dodecahedral, perfect	Opaque.	Reactions for sulphur; with soda on charcoal gives zinc coating.
5.5	Brittle.	4.4	I. Usually massive.	None.	Opaque. Sometimes magnetic.	Infusible; green bead with borax.
5.5	Brittle.	5.	I. Octahedrons, also massive.	Indistinct.	Opaque. Slightly magnetic.	Infusible; reactions for manganese; and zinc with borax and soda.
5.5	Brittle.	5.7	V. Also massive.	None.	Opaque.	Emerald green bead with SPh; green bead with soda.
5.5	Brittle.	4.9	III. Scaly, also massive or botryoidal.	Basal.	Opaque. Sometimes magnetic.	Infusible; becomes magnetic on charcoal; soluble with HCl.
5.	Brittle.	3.7	Massive and botryoidal.	None.	Opaque.	Like hematite, but yields water in closed tube.
5.	Brittle.	4.2	IV. Columnar, fibrous and botryoidal.	Prismatic, perfect.	Opaque.	Water in tube; magnetic on charcoal.
5.	Brittle.	3.8	Massive, fibrous and botryoidal.	None.	Opaque.	Like göthite.
5.5	Brittle.	4.	Cubes, octahedrons, etc.	Cubic.	Opaque to transparent.	Infusible; reactions for titanium.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
III. Color Black.—Continued.	4. Very Hard.	Strongly Magnetic.	**Magnetite** (23).	Fe_3O_4.	Metallic.	Black.	Black.
			Emery (25).	Al_2O_3 $+Fe_3O_4$.	Metallic.	Black to brown.	Black to bro[illegible]
		Streak black. Crystalline.	**Menaccanite** (25).	$(FeTi)_2O_3$.	Metallic.	Black.	Brownish bla[illegible]ck
			Columbite (35).	$FeCb\ O_6$.	Submetallic.	Black.	Brownish bla[illegible]ck.
		Streak black. Uncrystalline.	**Psilomelane** (32).	MnO_2 $+H_2O$.	Submetallic.	Iron-black.	Brownish black.
		Streak gray or light brown. G. about 7.	**Cassiterite** (26).	SnO_2.	Adamantine.	Black.	Gray to light brown
		Streak gray or light brown. G. about 4.	**Rutile** (26).	TiO_2.	Metallic to adamantine.	Black.	Gray to light brown
			Brookite (27).	TiO_2.	Metallic to adamantine.	Black.	Gray to light brown
			Allanite (55).	Complex silicate.	Submetallic.	Black.	Gray to light brown
		Streak dark reddish brown.	**Franklinite** (23).	$(FeZnMn)_3O_4$.	Metallic.	Iron-black.	Reddish brown.
			Samarskite (35).	Complex columbate.	Submetallic, shining.	Black.	Reddish brown.
		Streak red.	**Hematite** (25).	Fe_2O_3.	Metallic.	Black.	Red.
			Turgite (28). Comapre *Limonite*.	$2Fe_2O_3$ $+H_2O$.	Submetallic.	Reddish black.	Red.
IV. Color Gray.	1. Very Soft.	H. about 1.	**Molybdenite** (14).	MoS_2.	Metallic.	Lead-gray.	Lead-gray.
		H. about 2.	**Stibnite** (13).	Sb_2S_3.	Metallic.	Light lead-gray.	Lead-gray.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
6.5	Brittle.	5.	I. Usually massive.	Octahedral.	Opaque. Strongly magnetic.	Infusible; soluble in HCl.
7 to 9	Brittle.	4.5	III. Coarsely to finely granular.	None.	Opaque. Strongly magnetic.	Infusible and insoluble.
6.	Brittle.	4.75	III. Often laminated.	None.	Opaque. Often slightly magnetic.	Infusible; reactions for titanium.
6.	Brittle.	6.	IV. Usually in crystals.	Prismatic.	Opaque.	Infusible.
6.	Brittle.	4.2	Compact or botryoidal.	Even or conchoidal.	Opaque.	Infusible; water in closed tube; evolves chlorine with HCl.
6.5	Brittle.	6.8	II. Also massive and botryoidal.	Imperfect.	Opaque.	Infusible; yields metallic tin with soda on coarcoal.
6.25	Brittle.	4.2	II. Prismatic and twin crystals.	Prismatic, distinct.	Opaque.	Infusible; reactions for titanium.
6.	Brittle.	4.2	IV. Small square crystals.	Prismatic, indistinct.	Opaque.	Like rutile.
6.	Brittle.	3.6	V. Tabular and prismatic.	In traces.	Opaque.	Fuses with intumescence to a magnetic globule; gelatinizes with HCl.
6.5	Brittle.	5.	I. Octahedrons and massive.	Indistinct.	Opaque. Slightly magnetic.	Infusible; reactions for manganese and zinc with borax and soda.
6.	Brittle.	5.7	IV. Also massive.	None.	Opaque.	Emerald-green bead with SPh; green bead with soda.
6.5	Brittle.	4.9	III. Scaly, also compact and botryoidal.	Basal.	Opaque. Sometimes magnetic.	Infusible; magnetic on charcoal; soluble in HCl.
6.	Brittle.	3.7	Compact, botryoidal and earthy.	None.	Opaque.	Like hematite; but yields water in closed tube.
1.25	Sectile.	4.6	III. Usually foliated.	Basal, perfect.	Opaque. Greasy feel.	Infusible; reactions for sulphur.
2.	Brittle.	4.5	IV. Columnar to granular.	Pinacoidal, perfect.	Opaque.	Fuses very readily and gives antimony fumes and coating.

Analytical Key.		Species.	Composition.	Lustre.	Color.	Streak.
IV. Color Gray.—Continued.						
2. Soft.	Streak white or light gray.	**Arsenic** (3).	As.	Metallic.	White.	White.
		Antimony (3).	Sb.	Metallic.	White.	White.
	Streak dark gray.	**Stibnite** (13).	Sb_2S_3.	Metallic.	Light lead-gray.	Lead-gray.
		Galenite (6).	PbS.	Metallic.	Dark lead-gray.	Dark lead-gray.
		Chalcocite (9).	Cu_2S.	Metallic.	Blackish lead-gray.	Blackish lead-gray.
	Streak black.	**Tetrahedrite** (15).	$Cu_8Sb_2S_7$.	Metallic.	Dark gray to black.	Dark gray to black.
3. Hard.	Streak black. Malleable. Magnetic.	**Iron** (2).	Fe.	Metallic.	Iron-gray to black.	Iron-gray to black.
	Streak black. Brittle.	**Arsenopyrite** (11).	FeAsS.	Metallic.	White to gray.	Grayish black.
		Cobaltite (10).	CoAsS.	Metallic.	White to gray.	Grayish black.
		Smaltite (10).	$(CoFeNi)As_2$.	Metallic.	White to gray.	Grayish black.
	Streak red.	**Hematite** (25).	Fe_2O_3.	Metallic.	Gray to black.	Red.
4. Very Hard.	Streak grayish black.	**Marcasite** (11).	FeS_2.	Metallic.	Pale grayish yellow.	Grayish black.
		Arsenopyrite (11).	FeAsS.	Metallic.	White to gray.	Grayish black.
		Smaltite (10).	$(CoFeNi)As_2$.	Metallic.	White to gray.	Grayish black.
	Streak red.	**Hematite** (25).	Fe_2O_3.	Metallic.	Gray to black.	Red.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
3.5	Brittle.	6.	III. Massive or botryoidal.	Basal, imperfect.	Opaque. Dark gray tarnish.	Volatilizes without fusing, giving gray fumes and coating on charcoal, and metallic sublimate in tube.
3.5	Brittle.	6.6	III. Lamellar or massive.	Basal, perfect.	Opaque.	Fuses readily on charcoal, giving copious white fumes and a white coating.
2.5	Brittle.	4.5	IV. Columnar to massive.	Prismatic, perfect.	Opaque.	Fuses readily, giving antimony fumes and coating on charcoal.
2.75	Brittle.	7.5	I. Cubic and massive.	Cubic, perfect.	Opaque.	Fuses on charcoal, yielding metallic lead and sulphur fumes.
2.75	Brittle.	5.7	IV. Crystals, also massive.	Prismatic, indistinct.	Opaque. Dull black tarnish.	Fuses on charcoal; sulphur fumes; metallic copper with soda.
3.	Brittle.	4.8	I. Usually massive.	Uneven.	Opaque.	On charcoal gives antimony coating; with soda gives copper.
4.5	Malleable.	7.5	I. Usually compact.	Usually none.	Opaque. Strongly magnetic.	Infusible; soluble in HCl.
5.5	Brittle.	6.2	IV. Crystals and massive.	Prismatic, distinct.	Opaque.	On charcoal, arsenic coating, etc., and magnetic residue; in tube, arsenic sublimate.
5.5	Brittle.	6.2	IV. Crystals and massive.	Cubic, perfect.	Opaque.	Arsenic fumes and coating on charcoal; cobalt blue with borax.
5.5	Brittle.	7.	I. Usually massive.	Cubic, in traces.	Opaque.	Arsenic coating and magnetic residue on charcoal; arsenic sublimate in tube.
5.5	Brittle.	4.9	III. Scaly, also compact and botryoidal.	Basal.	Opaque. Sometimes magnetic.	Infusible; becomes magnetic on charcoal; soluble in HCl.
6.25	Brittle.	4.8	IV. Often globular, etc.	Prismatic, perfect.	Opaque.	On charcoal, sulphur fumes and magnetic residue; sulphur sublimate in tube.
6.	Brittle.	6.2	IV. Crystals, and massive.	Prismatic, distinct.	Opaque.	On charcoal, arsenic coating, etc., and magnetic residue; in tube, arsenic sublimate.
6.	Brittle.	7.	I. Usually massive.	Cubic, in traces.	Opaque.	On charcoal, arsenic coating and magnetic residue; in tube, arsenic sublimate.
6.5	Brittle.	4.9	III. Scaly, also compact and botryoidal.	Basal.	Opaque. Sometimes magnetic.	Infusible; magnetic on charcoal; soluble in HCl.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
III. Color White.	1. Very Soft.	Liquid.	**Mercury** (2).	Ag.	Metallic.	White.	White.
		Brittle.	**Bismuth** (3).	Bi.	Metallic.	Reddish white.	Reddish white.
		Malleable.	**Silver** (1).	Ag.	Metallic.	White.	White.
	2. Soft.	Brittle.	**Arsenic** (3).	As.	Metallic.	White.	White.
			Antimony (3).	Sb.	Metallic.	White.	White.
			Bismuth (3).	Bi.	Metallic.	Reddish white.	Reddish white.
		Malleable.	**Silver** (1).	Ag.	Metallic.	White.	White.
	3. Hard.	Ortho-rhombic.	**Arsenopyrite** (11).	FeAsS.	Metallic.	White to gray.	Grayish black.
		Isometric.	**Smaltite** (10).	$(CoFeNi)As_2$.	Metallic.	White to gray.	Grayish black.
			Cobaltite (10).	CoAsS.	Metallic.	White to gray.	Grayish black.
	4. Very Hard.	Ortho-rhombic.	**Arsenopyrite** (11).	$(CoFeNi)As_2$.	Metallic.	White to gray.	Grayish black.
		Isometrtc.	**Smaltite** (10).	FeAsS.	Metallic.	White to gray.	Grayish black.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
	Liquid.	13.5	Fluid globules.	None.	Opaque.	Volatile; dissolves in nitric acid.
2.	Brittle.	9.7	III. Massive and foliated.	Basal, perfect.	Opaque. Tarnishes.	Fuses and volatilizes, leaving yellow coating.
2.5	Malleable.	10.5	I. Grains, scales and threads.	None.	Opaque. Tarnishes black.	Infusible; soluble in nitric acid.
3.5	Brittle.	6.	III. Massive and botryoidal.	Basal, imperfect.	Opaque. Dark gray tarnish.	Volatilizes without fusing, giving gray flames and coating on charcoal and metallic sublimate in tube.
3.5	Brittle.	6.6	III. Lamellar or massive.	Basal, perfect.	Opaque.	Fuses readily on charcoal, giving copious white fumes and coating.
2.5	Brittle.	9.7	Massive and foliated.	Basal, perfect.	Opaque. Tarnishes.	On charcoal, fuses and volatilizes, leaving yellow volatile coating.
3.	Malleable.	10.5	I. Grains, scales and threads.	None.	Opaque. Tarnishes black.	Fusible; soluble in nitric acid.
5.5	Brittle.	6.2	IV. Crystals and massive.	Prismatic, distinct.	Opaque.	Arsenical coating and magnetic residue; arsenic sublimate in tube.
5.5	Brittle.	7.	I. Usually massive.	Cubic, in traces.	Opaque.	Like arsenopyrite; but blue bead with borax.
5.5	Brittle.	6.2	Crystals and massive.	Cubic, perfect.	Opaque.	Arsenic fumes and coating on charcoal; blue bead with borax.
6.	Brittle.	6.2	IV. Crystals and massive.	Prismatic, distinct.	Opaque.	Arsenic coating and magnetic residue; arsenic sublimate in tube.
6.	Brittle.	7.	I. Usually massive.	Cubic, in traces.	Opaque.	Like arsenopyrite; but blue bead with borax.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
1. Streak Red or Brown.	1. Very Soft.	Streak red. H. under 2. G. under 4.	**Turgite** (Red Ochre) (28). Compare *Hematite and Red Kaolinite.*	$2Fe_2O_3+H_2O$.	Dull.	Red.	Red.
			Realgar (12).	AsS.	Resinous.	Aurora-red.	Orange to aurora-red.
		Streak red. H. over 2. G. 5 to 6.	**Proustite** (15).	Ag_3AsS_3.	Adamantine.	Cochineal-red.	Cochineal-red.
			Pyrargyrite (15).	Ag_3SbS_3.	Adamantine.	Black to cochineal-red.	Cochineal-red.
		Streak red. H. over 2. G. 9.	**Cinnabar** (8).	HgS.	Adamantine.	Cochineal-red.	Scarlet.
		Streak dark brown to black. G. 1 to 1.5	**Asphaltum** (84).	C,H,O, etc.	Resinous.	Brownish black.	Dark brown.
			Brown Coal (84).	C,H,O, etc.	Resinous.	Brown to black.	Dark brown.
		Streak dark brown to black. G. 3 to 4.	**Wad** (32).	$2MnO_2+H_2O$.	Dull.	Brownish black.	Brownish black.
	2. Soft.	Streak orange. G. 5 to 6.	**Zincite** (21).	ZnO.	Subadamantine.	Deep red to orange.	Orange.
		Streak brownish red. G. 6.	**Cuprite** (20).	Cu_2O.	Adamantine to dull.	Red to brown.	Red to brown.
		Streak dull brown. G. 4.	**Sphalerite** (7).	ZnS.	Resinous.	Brown.	Brown to yellow.
		Streak pinkish white. G. 2.3	**Laumontite** (67).	$CaAl_2Si_4O_{12}+4H_2O$.	Vitreous.	Red.	Reddish white.
	3. Hard.	Streak deep red or orange.	**Turgite** (28).	$2Fe_2O_3+H_2O$.	Submetallic to silky.	Reddish black to red.	Red.
			Cuprite (20).	Cu_2O.	Submetallic or adamantine.	Red to brown.	Red to brown.
			Zincite (21).	ZnO.	Subadamantine.	Deep red to orange.	Orange.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
1.	Brittle.	3.7	Compact.	Earthy.	Opaque.	Water in tube; black and magnetic on charcoal.
1.75	Brittle.	3.5	V. Also massive.	Clinopinacoidal and basa .	Translucent.	Volatile and combustible, burning with a blue flame and arsenical odor.
2.25	Brittle.	5.5	III. Also massive.	Conchoidal.	Translucent.	Reactions for arsenic and silver.
2.25	Brittle.	5.8	III. Also massive.	Conchoidal.	Translucent.	Reactions for antimony and silver.
2.25	Brittle to flexible.	9.	III. Usually massive.	Subconchoidal.	Usually opaque.	Volatile; with soda in tube a sublimate of mercury.
1.	Brittle to flexible.	1.3	Massive.	Conchoidal.	Opaque.	Fuses and burns with flames.
1.5	Brittle.	1.25	Massive or laminated.	Even or conchoidal.	Opaque.	Infusible; but readily ignited, burning with flame.
1.	Earthy.	3.8	Amorphous.	Earthy.	Opaque.	Water in closed tube; amethystine bead with borax; chlorine with HCl.
4.	Brittle.	5.6	III. Also massive.	Basal, perfect.	Opaque.	Infusible; zinc coating with soda on charcoal; soluble in acid.
3.5	Brittle.	6.	I. Also capillary and massive.	Octahedral.	Usually impure and opaque.	Colors flame green, and fuses readily, yielding metallic copper.
3.5	Brittle.	4.	I. Also massive and compact.	Dodecahedral, perfect.	Translucent to opaque.	Like zincite; but reacts for sulphur and soluble with effervescence.
3.5	Brittle.	2.3	V. Also columnar.	Crumbles on exposure.	Transparent to opaque.	Fuses with intumescence; water in closed tube; jelly with HCl.
5.	Brittle.	3.7	Massive, botryoidal, fibrous, etc.	Uneven.	Opaque.	Water in closed tube; magnetic on charcoal.
4.	Brittle.	6.	I. Also capillary and massive.	Octahedral.	Usually impure and opaque.	Colors flame green, and fuses readily, yielding metallic copper.
4.5	Brittle.	5.6	III. Also massive.	Basal, perfect.	Opaque.	Infusible; zinc coating with soda on charcoal; soluble in acid.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
I. *Streak Red or Brown.—Continued.*	3. *Hard.—Continued.*	Streak yellowish brown.	**Göthite** (29).	$Fe_2O_3 + H_2O$.	Imperfect adamantine.	Brown.	Yellowish brown.
			Limonite (30).	$2Fe_2O_3 + 3H_2O$.	Submetallic to silky.	Brown to black.	Yellowish brown.
			Sphalerite (7).	ZnS.	Resinous.	Brown to black.	Yellow to brown.
			Brookite (27).	TiO_2.	Adamantine to submetallic.	Brown to black.	Gray to yellowish brown.
		Streak dark reddish brown to black.	**Columbite** (35).	$FeCb_2O_6$.	Submetallic.	Black.	Brownish black.
			Samarskite (35).	Complex columbate.	Submetallic, shining.	Black.	Reddish brown.
			Wolframite (41).	$(FeMn)WO_4$.	Submetallic.	Brownish black.	Brownish black.
			Psilomelane (32). Compare *Manganite*.	$MnO_2 + H_2O$.	Submetallic.	Iron-black.	Brownish black.
	4. *Very Hard.*	Streak deep red. G. 3.6	**Turgite** (28).	$2Fe_2O_3 + H_2O$.	Submetallic.	Reddish black.	Red.
		Streak pale red or brown. G. 2.6	**Quartz** (Jasper) (33).	$SiO_2 + Fe_2O_3$.	Nearly dull.	Red and brown.	Light red or brown.
			Quartz (Ferruginous quartz) (33).	$SiO_2 + Fe_2O_3$.	Vitreous to nearly dull.	Red or brown.	Light red or brown.
		Streak pale brown. G. above 4.	**Rutile** (26).	TiO_2.	Adamantine.	Brown.	Light brown.
			Brookite (27).	TiO_2.	Adamantine.	Brown.	Light brown.
			Cassiterite (26). Compare *Columbite, Samarskite, Psilomelane and Chromite.*	SnO_2.	Adamantine.	Brown to black.	Gray to light brown.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5.25	Brittle.	4.2	IV. Usually massive, fibrous or botryoidal.	Prismatic, perfect.	Opaque.	Water in closed tube; magnetic on charcoal.
5.25	Brittle.	4.	Compact, botryoidal, fibrous etc.	Uneven, splintery, etc.	Opaque.	Like göthite.
4.	Brittle.	4.	I. Usually massive.	Dodecahedral, perfect.	Translucent to opaque.	Reactions for sulphur and zinc; soluble in acid with effervescence.
5.5	Brittle.	4.2	IV. Small square crystals.	Prismatic, indistinct.	Translucent to opaque.	Infusible; reactions for titanium.
6.	Brittle.	6.	IV. Usually in crystals.	Prismatic.	Opaque.	Infusible.
5.5	Brittle.	5.7	IV. Also massive.	None.	Opaque.	Emerald-green bead with sulphur; green bead with soda.
5.25	Brittle.	7.4	V. Also lamellar or massive.	Prismatic, perfect.	Opaque.	Fuses easily to a magnetic globule; reactions for manganese and tungsten.
5.	Brittle.	4.2	Compact and botryoidal.	Even or conchoidal.	Opaque.	Infusible; water in closed tube; evolves chlorine with HCl.
5.	Brittle.	3.7	Compact and botryoidal.	None.	Opaque.	Infusible; magnetic on charcoal; soluble in HCl: water in closed tube.
7.	Brittle.	2.6	III. Compact.	None.	Translucent to opaque.	Infusible and insoluble.
7.	Brittle.	2.6	III. Often massive.	None.	Translucent to opaque.	Infusible and insoluble.
6.25	Brittle.	4.2	II. Prismatic and twin crystals.	Prismatic, distinct.	Translucent to opaque.	Infusible; reactions for titanium.
6.	Brittle.	4.2	IV. Small square crystals.	Prismatic, indistinct.	Translucent to opaque.	Like rutile.
5.5	Brittle.	6.8	II. Also massive and botryoidal.	Imperfect.	Translucent to opaque.	Infusible; yields metallic tin with soda on charcoal.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
II. Streak Yellow.	1. Very Soft.	G. 2 to 2.5	**Sulphur** (4).	S.	Resinous.	Yellow.	Yellow.
			Kaolinite (Yellow clay) (78).	$Al_2Si_2O_7 + 2H_2O$.	Dull.	Yellow.	Yellow.
		G. 3.5 to 4.	**Orpiment** (13).	As_2S_3.	Resinous to pearly.	Yellow.	Yellow.
			Limonite (Yellow ochre) (30).	$2Fe_2O_3 + 3H_2O$.	Dull.	Yellow.	Yellow.
	2. Soft.	Streak brownish yellow.	**Sphalerite** (7).	ZnS.	Resinous.	Brown to yellow.	Yellowish brown.
		Streak orange.	**Zincite** (21).	ZnO.	Subadamantine.	Deep red to orange.	Orange.
		Streak pale yellow. G. 3.1	**Autunite** (38).	$CaU_2P_2O_{12} + 10H_2O$.	Adamantine to pearly.	Yellow.	Yellow.
		Streak pale yellow. G. 6 to 7.	**Wulfenite** (41).	$PbMoO_4$.	Resinous to adamantine.	Yellow.	Yellowish white.
			Vanadinite (36).	$3Pb_3V_2O_8 + PbCl_2$.	Resinous to dull.	Brown to yellow.	Yellowish.
	3. Hard.	Streak orange.	**Zincite** (21).	ZnO.	Subadamantine.	Deep red to orange.	Orange.
		Streak brownish yellow.	**Göthite** (29).	$Fe_2O_3 + H_2O$.	Adamantine, imperfect.	Brown.	Yellow.
			Limonite (30).	$2Fe_2O_3 + 3H_2O$.	Submetallic to silky.	Brown to black.	Yellow.
	4. Very Hard.	Compact.	**Quartz** (Jasper) (33).	$SiO_2 + Fe_2O_3$.	Nearly dull	Brown to yellow.	Light yellow.
		Crystalline.	**Quartz** (Ferruginous Quartz) (33).	$SiO_2 + Fe_2O_3$.	Vitreous to nearly dull.	Brown to yellow.	Light yellow.
			Compare *Rutile, Brookite and Cassiterite.*				

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
2.	Brittle.	2.	IV. Often massive.	Imperfect.	Translucent. Electric by friction.	Burns with blue flame and sulphurous odor.
1.	Plastic to earthy.	2.5	IV. Usually compact or clayey.	Earthy.	Opaque.	Infusible and insoluble; water in tube.
2.	Sub-sectile.	3.5	IV. Usually foliated or massive.	Macropinacoidal, perfect.	Translucent.	Volatilizes and gives reactions for arsenic and sulphur.
1.	Earthy.	3.7	Earthy.	None.	Opaque.	Magnetic on charcoal; water in closed tube.
	Brittle.	4.	I. Usually massive.	Dodecahedral, perfect.	Translucent to opaque.	Reactions for sulphur and zinc; soluble in acid with effervescence.
	Brittle.	5.6	III. Also massive.	Basal, perfect.	Opaque.	Infusible; zinc coating with soda on charcoal; soluble in acid.
	Brittle.	3.1	IV. Square and tabular.	Basal, perfect.	Translucent.	Fuses to a black mass; soluble in acid; water in closed tube.
	Brittle.	6.5	II. Very thin tabular crystals.	Octahedral, distinct.	Translucent.	Fuses readily, and yields lead with soda on charcoal.
	Brittle.	7.	III. Usually incrusting.	None.	Translucent to opaque.	Fuses readily; yields lead with soda on charcoal; and reacts for chlorine with copper oxide.
5	Brittle.	5.6	III. Also massive.	Basal, perfect.	Opaque.	Infusible; zinc coating with soda; soluble in acids.
.25	Brittle.	4.2	IV. Usually massive, fibrous or botryoidal.	Prismatic, perfect.	Opaque.	Water in closed tube; magnetic on charcoal.
5.25	Brittle.	4.	Compact, botryoidal, fibrous, etc.	Uneven, splintery, etc.	Opaque.	Like göthite.
7.	Brittle.	2.6	III. Compact.	None.	Translucent to opaque.	Infusible and insoluble.
7.	Brittle.	2.6	III. Often massive.	None.	Translucent to opaque.	Infusible and insoluble.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
III. *Streak Black.*	1. *Very Soft.*	G. 3.8	**Wad** (32).	Mn_2O $+H_2O$.	Dull.	Black.	Black.
		G. under 2.5	**Asphaltum** (84).	C,H,O,etc.	Resinous.	Brownish black.	Brownish black
			Mineral Coal (84).	C,H,O,etc.	Resinous to submetallic.	Brown to black.	Brown to black
			Kaolinite (carbonaceous) (78).	$Al_2Si_2O_7$ $2H_2O$.	Dull.	Black.	Black.
	2. *Soft.*	G. over 6.	**Melaconite** (22).	CuO.	Metallic to dull.	Black.	Black.
	3. *Hard.*	Amorphous. G. under 5.	**Psilomelane** (32).	MnO_2 $+H_2O$.	Submetallic.	Black.	Brownish black.
		Crystalline. G. over 5.	**Samarskite** (35).	Complex columbate.	Submetallic, shining.	Black.	Reddish bro[illegible]
			Wolframite (41). Compare *Columbite.*	(FeMn) WO_4.	Submetallic.	Brownish black.	Brownish blac[illegible]
	4. *Very Hard.*	Crystalline. G. over 5.	**Columbite** (35). Compare *Psilomelane and Samarskite.*	$FeCb_2O_6$.	Submetallic.	Black.	Brownish black.

.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
	Earthy.	3.8	Amorphous.	Earthy.	Opaque.	Yields water in closed tube; amethystine bead with borax; evolves chlorine with HCl.
	Brittle to flexible.	1.3	Amorphous.	Conchoidal.	Opaque.	Fuses and burns with flame.
	Brittle.	1.5	Amorphous.	Even.	Opaque.	Infusible; burns.
	Earthy.	2.5	IV. Earthy.	Earthy.	Opaque.	Infusible; water in tube.
	Brittle to earthy.	6.25	IV. Usually massive or earthy.	Uneven or earthy.	Opaque.	Infusible; copper with soda on charcoal; green solution with nitric acid.
	Brittle.	4.2	Compact or botryoidal.	Even or conchoidal.	Opaque.	Infusible; water in closed tube; evolves chlorine with HCl.
;	Brittle.	5.7	IV. Also massive.	None.	Opaque.	Emerald-green bead with sulphur; green bead with soda.
5	Brittle.	7.4	V. Also lamellar or massive.	Prismatic, perfect.	Opaque.	Fuses easily to a magnetic globule; reacts for manganese and tungsten.
	Brittle.	6.	IV. Usually in crystals.	Prismatic.	Opaque.	Infusible.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
IV. Streak Green or Blue.	1. Very Soft.	Streak green.	**Glauconite** (76).	$(AlFeK)SiO_3+H_2O$.	Dull.	Dark green.	Lighter green.
			Prochlorite (81).	$(AlMgFe)_5SiO_5+H_2O$.	Pearly to dull.	Dark green.	Lighter green.
			Ripidolite (81).	$Al_2Mg_5Si_3O_{14}+4H_2O$.	Pearly.	Deep green.	Greenish.
		Streak blue.	**Vivianite** (37).	$Fe_3P_2O_8+8H_2O$.	Vitreous to pearly or dull.	Blue to green.	Bluish.
	2. Soft.	Streak green. Not micaceous.	**Atacamite** (17).	$CuCl_2+3H_2CuO_2$.	Adamantine to vitreous.	Green.	Apple-green.
			Malachite (46). Compare *Chrysocolla*.	$Cu_2CO_4+H_2O$.	Adamantine, silky or dull.	Green.	Paler green.
		Streak green. Micaceous.	**Lepidomelane** (56). Compare *Ripidolite*.	$(AlFeK)_2SiO_4$.	Adamantine to pearly.	Black.	Grayish green.
		Streak blue.	**Azurite** (46).	$Cu_3C_2O_7+H_2O$.	Vitreous to dull.	Blue.	Paler blue.
			Chrysocolla (68).	$CuSiO_3+2H_2O$.	Vitreous to dull.	Bluish green.	Bluish.
	3. Hard.	Streak greenish	**Pyroxene** (Augite) (47).	$(CaMgAlFe)SiO_3$.	Vitreous.	Greenish black.	Grayish green.
			Amphibole (49) (Hornblende). Compare *Malachite*.	$(CaMgAlFe)SiO_3$.	Vitreous.	Greenish black.	Grayish green.
		Streak blue.	**Lapis-Lazuli** (57).	$(CaNaAl)_2SiO_4$.	Vitreous.	Blue.	Blue.
	4. Very Hard.	Streak bluish or greenish.	**Turquois** (38).	$Al_2P_2O_8+5H_2O$.	Waxy.	Blue.	Bluish to greenish white.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
1.	Granular and earthy.	2.3	Amorphous.	Earthy.	Opaque.	Water in closed tube.
1.5	Somewhat sectile.	2.8	III. Usually finely foliated.	Basal, perfect.	Translucent to opaque.	Fuses with difficulty; water in closed tube.
2.	Flexible and sectile.	2.7	V. Foliated or micaceous.	Basal, perfect.	Translucent. Emerald-green by trans. light.	Like prochlorite.
2.	Sectile to earthy.	2.6	V. Often massive or earthy.	Clinopinacoidal, perfect.	Transparent to opaque.	Fuses easily to magnetic globule; water in closed tube; soluble in acid.
3.25	Brittle.	3.75	IV. Also massive.	Brachypinacoidal, perfect.	Translucent to opaque.	Fuses with blue flames; yields metallic copper; water in closed tube.
3.75	Brittle.	3.9	V. Often botryoidal, fibrous or earthy.	Basal, perfect.	Translucent to opaque.	Fuses and yields copper; water in closed tube; effervesces with acid.
3.	Sectile to brittle.	3.	III. Foliated or micaceous.	Basal, perfect.	Translucent to opaque.	Fuses to magnetic globule; decomposed by HCl.
4.	Brittle.	3.7	V. Also massive.	Clinodome, perfect.	Translucent to opaque.	Like malachite.
3.	Brittle to sectile.	2.2	Amorphous or botryoidal.	Conchoidal or uneven.	Translucent to opaque.	Infusible; water in closed tube; copper on charcoal; decomposed by HCl.
5.5	Brittle.	3.4	V. Massive or fibrous.	Prismatic, perfect.	Translucent to opaque.	Fusible; insoluble.
5.5	Brittle.	3.2	V. Massive or fibrous.	Prismatic, perfect.	Translucent to opaque.	Like pyroxene.
5.5	Brittle.	2.4	I. Usually massive.	None.	Opaque.	Fusible; gelatinizes with HCl.
6.	Brittle.	2.7	Amorphous.	None.	Opaque.	Infusible; water in closed tube; soluble in acid.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
V. Streak White or Gray.	I. Very Soft.	G. 5.5 Waxy.	**Cerargyrite** (16).	$AgCl$.	Resinous to dull.	Gray.	Gray, shi[illegible]
		Micaceous, foliæ elastic.	**Muscovite** (56).	$AlKSiO_4$.	Pearly.	White, brown, green, etc.	White.
			Ripidolite (81).	$Mg_5Al_2Si_3O_{14}+4H_2O$.	Pearly.	Deep green.	White.
		Greasy feel. Foliated or compact.	**Talc** (75).	$MgSiO_3+H_2O$.	Pearly to dull.	Green to gray, etc.	White.
			Pyrophyllite (75).	$Al_2Si_3O_9+H_2O$.	Dull to pearly.	White, gray, green, etc.	White.
		Compact. Floats on water when dry.	**Sepiolite** (76).	$Mg_2Si_3O_8+2H_2O$.	Dull.	White to gray.	White.
		Compact, earthy or clayey.	**Kaolinite** (78).	$Al_2Si_2O_7+2H_2O$.	Dull to pearly.	White, gray, yellow, red, blue, green, etc.	Like color.
			Calcite (Chalk) (44).	$CaCO_3$.	Dull.	White.	White.
			Opal (Tripolite and Siliceous Tufa) (34).	SiO_2+H_2O.	Dull.	White to gray.	White to gra[illegible]
		Blue or green.	**Vivianite** (37).	$Fe_3P_2O_8+8H_2O$.	Vitreous to pearly or dull.	Blue to green.	Whitish.
		Very light, fibrous nodules.	**Ulexite** (40).	$NaCaB_5O_9+5H_2O$.	Silky to dull.	White.	White.
		Soluble in water, having taste.	**Sassolite** (39).	$H_6B_2O_6$.	Pearly.	White.	White.
			Borax (40). Compare *Halite*.	$Na_2B_4O_7+10H_2O$.	Vitreous to resinous.	White.	White.
		Yields much water in closed tube.	**Brucite** (31).	$MgO+H_2O$.	Pearly to silky.	White.	White.
			Gypsum (43).	$CaSO_4+2H_2O$.	Pearly to dull.	White, gray, brown, etc.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
1.5	Waxy and sectile.	5.5	I. Usually compact.	None.	Transparent to opaque.	Fuses; silver on charcoal; reacts for chlorine with CuO and SPh.
2.	Sectile and elastic.	2.8	V. Usually foliated or lamellar.	Basal, perfect.	Transparent to translucent. Transparent.	Infusible and insoluble.
2.	Flexible and sectile.	2.7	V. Foliated or micaceous.	Basal, perfect.	Emerald-green by transmitted light.	Fuses with difficulty; water in closed tube.
1.	Sectile and inelastic.	2.6	IV. Usually foliated, sometimes compact.	Basal, perfect.	Greasy feel. Translucent.	Infusible and insoluble; little water in closed tube.
1.5	Somewhat sectile.	2.8	IV. Usually compact, sometimes foliated.	Basal, perfect.	Greasy feel. Translucent to opaque.	Fuses with difficulty; yields water; blue color with cobalt solution.
2.25	Somewhat sectile.	Very light.	Compact.	None.	Opaque.	Infusible; water in closed tube; pink color with cobalt solution; gelatinizes with HCl.
1.5	Plastic or earthy.	2.5	IV. Usually compact or clayey.	Basal, perfect. Finely scaly.	Translucent to opaque.	Infusible and insoluble; water in closed tube; blue color with cobalt solution.
1.	Earthy.	2.6	III. Compact.	Earthy.	Opaque.	Infusible; soluble with effervescence; alkaline reaction after heating.
1.	Earthy.	1.65	Amorphous.	Earthy.	Opaque.	Infusible; water in tube.
2.	Sectile to earthy.	1.5	V. Often massive or earthy.	Clinopinacoidal, perfect.	Transparent to opaque.	Fuses easily to magnetic globule; water in closed tube; soluble in acid.
1.	Sectile.	1.7	Nodules.	Finely fibrous.	Opaque.	Fuses readily to a clear glass, coloring flame yellow; with H_2SO_4 the flame is green.
1.	Brittle.	2.4	VI. Scaly.	Basal, perfect.	Translucent. Taste acidulous.	Fuses to a clear glass, coloring flame green; soluble in water; water in closed tube.
2.25	Brittle.	2.3	V. Usually crystallized.	Perfect.	Translucent to opaque. Taste alkaline.	Puffs up and fuses to clear glass, coloring flame yellow; soluble in water; water in closed tube.
2.	Flexible and sectile.	2.5	III. Usually foliated or fibrous.	Basal, perfect.	Translucent.	Infusible; alkaline after heating; red with cobalt solution; water in tube; soluble in acid.
2.	Sectile to brittle.	2.	V. Usually foliated, massive or fibrous.	Clinopinacoidal, perfect.	Transparent to opaque.	Fuses; water in closed tube; sulphur reaction with soda on charcoal.

Analytical Key.				Species.	Composition	Lustre.	Color.	Streak.
V. Streak: White or Gray.—Continued.	2. Soft.	G. above 3.5.	G. above 6.	Green or brown.	Pyromorphite (36).	$3Pb_3P_2O_8 + PbCl_2$.	Resinous.	Green to brown.	White.
					Mimetite (36).	$3Pb_3As_2O_8 + PbCl_2$.	Resinous.	Pale yellow.	White.
				Yellow.	Vanadinite (36).	$3Pb_3V_2O_8 + PbCl_2$.	Resinous.	Yellow to brown.	Yellowish white.
					Wulfenite (41).	$PbMoO_4$.	Resinous.	Yellow.	White.
				White.	Anglesite (42).	$PbSO_4$.	Adamantine to vitreous.	White.	White.
					Cerussite (45).	$PbCO_3$.	Adamantine to vitreous.	White.	White.
			G. below 6.	Red, brown or gray.	Rhodochrosite (44).	$MnCO_3$.	Vitreous.	Rose red to brown.	White.
					Siderite (44).	$FeCO_3$.	Vitreous.	Gray to brown.	Nearly white.
					Smithsonite (44).	$ZnCO_3$.	Vitreous to dull.	Gray, yellow, to brown.	Whitish.
					Sphalerite (7).	ZnS.	Resinous.	Yellowish brown.	Whitish.
					Calamine (69).	$Zn_2SiO_4 + H_2O$.	Vitreous to dull.	Gray, yellow, to brown.	Whitish.
				White or bluish or greenish.	Barite (42).	$BaSO_4$.	Vitreous.	White to bluish or brownish.	White.
					Celestite (42).	$SrSO_4$.	Vitreous.	White to bluish.	White.
					Witherite (45).	$BaCO_3$.	Vitreous.	White.	White.
					Strontianite (45).	$SrCO_3$.	Vitreous.	White to greenish.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
3.75	Brittle.	6.8	III. Often botryoidal or massive.	Traces.	Translucent.	Readily fusible; lead with soda on charcoal; chlorine with CuO and SPh; white sublimate in tube.
3.5	Brittle.	7.2	III. Also massive.	Imperfect.	Translucent.	Like pyromorphite, but gives arsenical odor.
2.75	Brittle.	7.	III. Usually in incrustations.	None.	Opaque.	Like pyromorphite, but gives test for vanadium.
3.	Brittle.	6.7	II. Very thin, square, tabular crystals.	Octahedral.	Translucent.	Fuses readily; lead on charcoal with soda.
3.	Brittle.	6.25	IV. Also massive and stalactitic.	Prismatic, interrupted.	Transparent to opaque.	Fuses readily; lead with soda on charcoal; coin test for sulphur.
3.5	Brittle.	6.5	IV. Also massive and stalactitic.	Prismatic, imperfect.	Transparent to opaque.	Fuses readily; lead with soda on charcoal; effervescence with acid.
4.	Brittle.	3.6	III. Also massive and botryoidal.	Rhombohedral, perfect.	Translucent.	Infusible; amethystine borax bead; soluble with effervescence.
4.	Brittle.	3.8	III. Also compact and concretionary.	Rhombohedral, perfect.	Translucent to opaque.	Infusible; blackens and becomes magnetic; effervesces in hot acid.
2 to 4	Brittle to friable.	4.	III. Compact to earthy.	None.	Opaque.	Infusible; effervesces with HCl; zinc coating on charcoal.
3.75	Brittle.	4.	I. Also massive.	Dodecahedral, perfect.	Translucent to opaque.	Infusible; zinc coating with soda on charcoal; evolves H_2S with HCl.
2 to 4	Brittle to friable.	3.5	IV. Compact to earthy.	None.	Opaque.	Infusible; yields water; green color with cobalt solution; gelatinizes with HCl.
3.	Brittle.	4.5	IV. Also massive and stalactitic.	Basal and prismatic, perfect.	Transparent to opaque.	Fuses; colors flame yellowish green; sulphur reaction with soda on silver.
3.25	Brittle.	4.	IV. Also massive, fibrous, globular, etc.	Basal and prismatic, perfect.	Transparent to opaque.	Like barite; but colors flame red.
3.5	Brittle.	4.3	IV. Also globular, etc.	Prismatic, distinct.	Translucent to opaque.	Fusible; colors flame yellowish green; effervesces with acid.
3.75	Brittle.	3.7	IV. Also globular, etc.	Prismatic, perfect.	Transparent to opaque.	Infusible; colors flame red; effervesces with acid.

Analytical Key.					Species.	Composition.	Lustre.	Color.	Streak.
V. Streak: White or Gray.—Continued.	2. Soft.—Continued.	G. below 3.5.	Micaceous.	Black, even in thin foliæ.	**Biotite** (56).	$(K_2MgFeAl)_2SiO_4$.	Pearly, splendent.	Black to deep green and brown.	White.
					Lepidomelane (56).	$(K_2FeAl)_2SiO_4$.	Adamantine to pearly.	Black.	Grayish green.
				Deep green.	**Ripidolite** (81).	$Al_2Mg_5Si_3O_{14}+4H_2O$.	Pearly.	Deep green.	Greenish.
				Foliæ elastic.	**Phlogopite** (56).	$(K_2MgAl)_2SiO_4$.	Pearly to submetallic.	Yellowish brown.	White.
					Muscovite (56).	$(K_2Al)_2SiO_4$.	Pearly.	White, brown, pale green, etc.	White.
					Lepidolite (56).	$(Li_2K_2Al)_2SiO_4$.	Pearly.	Rose-red and violet to white.	White.
					Hydromica (80).	$(K_2Al)_2SiO_4$.	Pearly.	White to greenish.	White.
				Foliæ brittle.	**Margarite** (82).	$(CaFeAl)_3SiO_5+H_2O$.	Pearly.	Reddish white to gray.	White.
			Effervesce with	Dilute HCl.	**Calcite** (44).	$CaCO_3$.	Vitreous to dull.	White, and all colors when impure.	White to gray.
					Aragonite (45).	$CaCO_3$.	Vitreous to dull.	White to gray, etc.	White.
				Strong HCl.	**Dolomite** (44).	$(CaMg)CO_3$.	Vitreous to dull.	White to gray, etc.	White.
					Magnesite (44).	$MgCO_3$.	Vitreous to dull.	White to gray, etc.	White.
				Saline taste.	**Halite** (16).	NaCl.	Vitreous.	White to gray.	White.
				Fibrous or acicular.	**Serpentine** (Chrysotile) (77).	$Mg_2SiO_4+H_2O$.	Silky.	Green to yellow.	White.
					Wavellite (38).	$Al_3P_4O_{19}+12H_2O$.	Vitreous.	White to green, brown, etc.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
2.75	Elastic and sectile.	2.9	III. Tabular or foliated.	Basal, very perfect.	Transparent to opaque.	Fuses with difficulty; decomposed by H_2SO_4; reactions for iron.
3.	Sectile to brittle.	3.	III. Tabular or foliated.	Basal, perfect.	Translucent to opaque.	Fuses to magnetic globule; decomposed by HCl.
2.5	Flexible and sectile.	2.7	V. Tabular or foliated.	Basal, perfect.	Transparent. Emerald-green by trans. light.	Fuses with difficulty; much water in closed tube.
2.75	Elastic and sectile.	2.8	IV. Tabular or foliated.	Basal, very perfect.	Transparent to translucent.	Fuses with difficulty; decomposed by H_2SO_4.
2.5	Elastic and sectile.	2.8	V. Tabular or foliated.	Basal, very perfect.	Transparent to translucent.	Infusible and insoluble; water in closed tube.
3.	Elastic and sectile.	2.9	IV. Tabular or foliated.	Basal, very perfect.	Translucent.	Fuses with intumescence, coloring the flame purplish red.
2.5	Elastic and sectile.	2.75	Tabular or foliated.	Basal, perfect.	Translucent. Greasy feel.	Infusible; water in closed tube.
4.	Laminæ stiff and brittle.	3.	IV. Usually lamellar or foliated.	Basal, perfect.	Translucent.	Infusible; whitens; water in closed tube.
3.	Brittle.	2.7	III. Rhombohedrons, also massive, compact, etc.	Rhombohedral, perfect.	Transparent to opaque. Strong double refraction.	Infusible; glows; alkaline reaction after heating; effervesces in cold dilute acid.
3.75	Brittle.	2.9	IV. Prismatic, also stalactitic, etc.	Prismatic, imperfect.	Transparent to translucent.	Like calcite, but whitens and falls to pieces.
3.5	Brittle.	2.85	III. Rhombohedrons, also massive and compact.	Rhombohedral, imperfect.	Translucent to opaque.	Infusible; alkaline reaction after heating; does not effervesce freely in cold, dilute HCl.
4.	Brittle.	3.	III. Usually compact.	Rhombohedral, imperfect.	Transparent to opaque.	Like dolomite.
3.	Flexible and sectile.	2.2	Fibrous veins.	Delicately fibrous.	Translucent.	Infusible; water in closed tube.
3.75	Brittle.	2.3	IV. Usually in radiate, globular masses.	Prismatic, perfect to fibrous.	Translucent.	Swells up, colors flame green, but is infusible; blue color with cobalt solution; much water in tube.
2.5	Brittle.	2.2	I. Cubes, also massive.	Cubic, perfect.	Transparent to translucent. Saline taste.	Fuses, coloring flame deep yellow; soluble in water.

Analytical Key.				Species.	Composition.	Lustre.	Color.	Streak.
V. Streak White or Gray.—Continued.	2. Soft.—Continued.	G. below 3.5.	Distinctly crystalline or cleavable.	Octahedral cleavage.	**Fluorite** (18).	CaF_2.	Vitreous.	White, green, violet to blue, yellow, etc.	White.
				One perfect cleavage, tabular or foliated.	**Brucite**. (31).	$MgO + H_2O$.	Pearly.	White to greenish.	White.
					Stilbite (74).	$(CaNa_2)Al_2Si_6O_{16} + 6H_2O$.	Pearly.	White to yellow, brown and red.	White.
					Heulandite (74).	$(CaNa_2)Al_2Si_6O_{16} + 5H_2O$.	Pearly.	White to red, gray, and brown.	White.
				Not belonging to the foregoing.	**Cryolite** (19).	$Na_6Al_2F_{12}$.	Vitreous.	White to brown.	White.
					Laumontite (67).	$CaAl_2Si_4O_{12} + 4H_2O$.	Vitreous.	White to red.	White.
					Anhydrite (42).	$CaSO_4$.	Vitreous to pearly.	White to bluish or reddish.	White.
			Compact or imperfectly crystalline.	Yields little or no water in closed tube.	**Cryolite** (19).	$Na_6Al_2F_{12}$.	Vitreous.	White to brown.	White.
					Anhydrite (42).	$CaSO_4$.	Vitreous to pearly.	White to bluish or reddish.	White.
				Bluish green.	**Chrysocolla** (68).	$CuSiO_3 + 2H_2O$.	Vitreous to dull.	Bluish green to blue.	Whitish.
				White.	**Gibbsite** (31).	$Al_2O_3 + 3H_2O$.	Vitreous to pearly and dull.	White to gray.	White.
					Sepiolite (76).	$Mg_2Si_3O_8 + 2H_2O$.	Dull.	White.	White.
				Not belonging to the foregoing.	**Serpentine** (77).	$Mg_3Si_2O_7 + 2H_2O$.	Resinous, waxy, greasy.	Green, yellow, brown, etc.	White.
					Dewylite (77).	$H_2Mg_2Si_3O_9 + 4H_2O$.	Resinous to greasy.	Yellow to gray and greenish.	White.
					Pinite (79).	$K_2Al_4Si_5O_{17} + 3H_2O$.	Waxy to dull.	Gray to green.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
4.	Brittle.	3.2	I. Cubes, also massive.	Octahedral, perfect.	Transparent to opaque. Phosphorescent when heated.	Decrepitates, fuses and gives alkaline reaction; reaction for fluorine with K_2SO_4.
2.5	Flexible and sectile.	2.4	III. Usually foliated or fibrous.	Basal, perfect.	Translucent.	Infusible; alkaline after heating; red color with cobalt solution; water in closed tube; soluble in acid.
3.75	Brittle.	2.1	IV. Usually in sheaf-like aggregates.	Brachypinacoidal, perfect.	Transparent to translucent.	Fuses with intumescence; yields water; decomposed by HCl without gelatinizing.
3.75	Brittle.	2.2	V. Also globular and massive.	Clinopinacoidal, perfect.	Transparent to translucent.	Like stilbite.
2.5	Brittle.	3.	VI. Usually massive.	In three directions.	Translucent.	Fuses very easily, coloring flame yellow; fluorine reaction.
4.	Brittle.	2.3	V. Also columnar and massive.	Clinopinacoidal and prismatic, perfect.	Translucent; opaque and pulverulent on exposure.	Fuses with intumescence; yields water; gelatinizes with acid.
3.25	Brittle.	2.9	IV. Also fibrous, lamellar, and massive.	Pinacoidal and basal, perfect.	Transparent to opaque.	Fuses; alkaline reaction; sulphur reaction with soda and silver.
2.5	Brittle.	3.	VI. Usually massive.	Imperfect.	Translucent.	Fuses very easily, coloring flame yellow; fluorine reaction.
3.25	Brittle.	2.9	IV. Often compact.	None apparent.	Translucent to opaque.	Fuses; alkaline reaction: sulphur reaction with soda and silver.
3.	Brittle to sectile.	2.2	Compact, sometimes botryoidal.	None.	Translucent to opaque.	Infusible; colors flame green; yields water copper with soda on charcoal.
3.	Tough.	2.4	V. Usually stalactitic or incrusting.	Basal, perfect.	Translucent. Argillaceous odor.	Infusible; yields water; blue color with cobalt solution.
2.5	Somewhat sectile.	Very light.	Compact.	None.	Opaque. Absorbs water.	Infusible; water in closed tube; pink color with cobalt solution; gelatinizes with HCl.
3.5	Brittle.	2.6	Compact or fine granular.	None.	Translucent, Smooth feel.	Infusible; yields water.
2.5	Brittle.	2.2	Compact.	None.	Translucent.	Infusible; yields water.
3	Brittle.	2.7	Compact.	None.	Translucent to opaque.	Fuses; yields water.

V. Streak White or Gray.—Continued.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
3. Hard. G. 4 or above 4.	Small square crystals.		**Brookite** (27).	TiO_2.	Adamantine.	Brown to yellowish and reddish.	White to gray.
	Distinct crystals rare.	Gelatinizes with acid.	**Willemite** (51). Compare *Calamine*.	Zn_2SiO_4.	Vitreous to resinous, weak.	Yellowish, greenish and brownish.	White.
		Effervesces with acid.	**Smithsonite** (44).	$ZnCO_3$.	Vitreous to dull.	White to grayish, greenish, brownish.	White.
	Very dark colored—greenish and brownish to black.	Cleavage prismatic and nearly rectangular.	**Enstatite** (47).	$MgSiO_3$.	Vitreous to pearly.	Grayish and greenish to brown.	White to gray.
			Hypersthene (47).	$(MgFe)SiO_3$.	Pearly to metalloidal.	Dark brownish green to black.	Gray.
			Pyroxene (Augite) (47).	$(CaMgAlFe)SiO_3$.	Vitreous.	Dark green to black.	Greenish gray.
		Cleavage prismatic and distinctly oblique.	**Amphibole** (Hornblende) (49).	$(CaMgAlFe)SiO_3$.	Vitreous.	Dark green to black.	Greenish gray
			Titanite (65).	$CaTiSiO_5$.	Adamantine to resinous.	Dark brown to black.	White to gray
		Cleavage basal, perfect.	**Chloritoid** (82).	$(AlFeMg)_4SiO_6+H_2O$.	Pearly.	Dark grayish and greenish to black.	Grayish to greenish
		No distinct cleavage.	**Allanite** (55).	Complex silicate.	Submetallic to resinous.	Pitch-brown to black.	Gray.
	Blue.		**Lazulite** (38). Compare *Sodalite*.	$AlP_2O_8+H_2O$.	Vitreous.	Blue.	White.
G. below 4.	Crystallization distinctly prismatic, bladed, columnar or fibrous (asbestiform).	Little or no water in closed tube.	**Wollastonite** (47).	$CaSiO_3$.	Vitreous.	White to reddish.	White.
			Pyroxene (47).	$(CaMgFe)SiO_3$.	Vitreous.	Green to white.	White.
			Amphibole (Actinolite, Asbestus) (49).	$(CaMgFe)SiO_3$.	Vitreous to silky.	Green.	White.
			Amphibole (Tremolite Asbestus) (49).	$(CaMg)SiO_3$.	Vitreous to silky.	White.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5-5	Brittle.	4.2	IV. Rarely massive.	Imperfect.	Translucent.	Infusible and insoluble; reactic for titanium.
5-5	Brittle.	4.	III. Usually massive.	Imperfect.	Translucent.	Fuses with difficulty; gelatini with HCl.
5-	Brittle.	4.25	III. Often incrusting, botryoidal and earthy.	Rhombohedral, perfect.	Translucent to opaque.	Infusible; effervesces with H(zinc coating with soda on charc
5-5	Rather brittle.	3.2	IV. Also massive and lamellar.	Prismatic.	Translucent to opaque.	Infusible and insoluble.
5-5	Rather brittle.	3.4	IV. Also massive and lamellar.	Prismatic.	Translucent to opaque.	Fusible to a black magnetic m on charcoal.
5-5	Brittle.	3.4	V. Often massive and granular.	Prismatic.	Translucent to opaque.	Fusible; insoluble.
5-5	Brittle.	3.2	V. Often bladed or massive.	Prismatic.	Translucent to opaque.	Fusible; insoluble.
5-5	Brittle.	3.5	V. Squarish, wedge-shaped crystals.	Prismatic.	Translucent to opaque.	Fuses with intumescence; reacti for titanium.
5-75	Brittle.	3.5	V. or VI. Coarsely foliated.	Basal, perfect.	Translucent to opaque.	Infusible; yields water.
5-75	Brittle.	3.6	V. Also massive and in grains.	In traces.	Opaque.	Fuses with intumescence to a m netic mass.
5-5	Brittle.	3.	V. Octahedrons, sometimes massive.	Imperfect.	Opaque.	Whitens and yields water; b color is restored by cobalt soluti
5-	Tough.	2.8	V. Tabular or bladed to fibrous.	Distinct.	Translucent.	Fuses and gelatinizes with HCl
5-5	Rather brittle.	3.3	V. Sometimes bladed or fibrous.	Prismatic.	Translucent.	Fusible; insoluble.
5-5	Brittle to flexible.	3.2	V. Usually bladed, fibrous or asbestiform.	Prismatic.	Translucent.	Fusible; insoluble.
5-5	Brittle to flexible.	3.1	V. Usually bladed, fibrous or asbestiform.	Prismatic.	Translucent	Fusible; insoluble.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
V. *Streak White or Gray.—Continued.* 3. *Hard.—Continued.* 4. *below 4.—Continued.* Crystalline or cleavable, and not belonging to the foregoing. No water.	Crystallization prismatic, etc.—Continued.	Much water in tube.	**Pectolite (67).**	$Na_2Ca_4Si_6O_{17}+H_2O$.	Silky to vitreous.	White.	White.
			Thomsonite (71).	$2(CaNa_2)Al_2Si_2O_8+5H_2O$.	Vitreous to pearly.	White.	White.
			Natrolite (71).	$Na_2Al_2Si_3O_{10}+2H_2O$.	Vitreous.	White.	White.
	Compact, showing no trace of crystalline form or cleavage.	Little or no water in tube.	**Amphibole (49).** (Jade and Nephrite.)	$(CaMgFe)SiO_3$.	Vitreous.	White to green.	White to green.
			Wollastonite (47).	$CaSiO_3$.	Vitreous.	White to reddish.	White.
		Much water in tube.	**Datolite (64).**	$H_2Ca_2B_2Si_2O_{10}$.	Vitreous.	White to gray.	White.
			Calamine (69). Compare *Serpentine.*	$Zn_2SiO_4+H_2O$.	Vitreous.	White.	White.
	Distinct tetragonal trisoctahedrons.	No water.	**Leucite (57).**	$K_2Al_2Si_4O_{12}$.	Vitreous.	White to gray.	White.
		Much water.	**Analcite (72).**	$Na_2Al_2Si_4O_{12}+2H_2O$.	Vitreous.	White.	White.
		Gelatinize with HCl.	**Wollastonite (47).**	$CaSiO_3$.	Vitreous.	White.	White.
			Nephelite (59).	$Na_2Al_2Si_2O_8$.	Vitreous to greasy.	White to grayish or yellowish.	White.
			Sodalite (57).	$3Na_2Al_2Si_2O_8+2NaCl$.	Vitreous to greasy.	Gray, blue, green, white, yellow, etc.	White.
			Datolite (64).	$H_2Ca_2B_2Si_2O_{10}$.	Vitreous.	White to gray.	White.
		Very brittle to friable. Soluble in HCl.	**Apatite (36).**	$3Ca_2P_2O_8+CaCl_2$.	Vitreous.	Green, brown, yellow, white, etc.	White.
		Squarish wedge-shaped or oblique crystals.	**Titanite (65).**	$CaTiSiO_5$.	Adamantine to resinous.	Brown, yellow, green, black.	Whitish.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5.	Brittle.	2.7	V. Acicular or fibrous and radiate.	Orthopinacoidal perfect.	Translucent to opaque.	Fuses; yields water; gelatinizes with HCl.
5.25	Brittle.	2.4	IV. Columnar or acicular and radiate.	Macropinacoidal, distinct.	Translucent. Pyroelectric.	Fuses with intumescence; yields water; gelatinizes with HCl.
5.25	Brittle.	2.2	IV. Columnar, acicular or fibrous and radiate.	Prismatic, perfect.	Transparent to translucent.	Fuses; yields water; gelatinizes with HCl.
6.	Tough.	3.	V. Compact.	None.	Translucent.	Fusible; insoluble.
5.	Tough.	2.8	V. Compact.	None.	Translucent.	Fuses; gelatinizes with HCl.
5.5	Brittle.	2.9	V. Globular and compact.	None.	Translucent to opaque.	Fuses with intumescence; much water; gelatinizes with HCl; colors flame bright green.
4.75	Brittle.	3.6	IV. Also botryoidal and massive.	Prismatic, perfect.	Translucent.	Infusible; yields water; green color with cobalt solution; gelatinizes with HCl.
5.75	Brittle.	2.5	I. Always in rounded crystals.	None.	Translucent to opaque.	Infusible; blue color with HCl.
5.25	Brittle.	2.25	I. Rarely massive.	In traces.	Transparent to opaque.	Fuses; yields water; gelatinizes with HCl.
5.	Brittle to tough.	2.8	V. Cleavable or massive.	Distinct.	Translucent.	Fuses; gelatinizes with HCl.
5.75	Brittle.	2.5	III. Usually cleavable or massive.	Distinct.	Transparent to opaque.	Fuses; gelatinizes with HCl.
5.75	Brittle.	2.3	I. Dodecahedrons and massive.	Dodecahedral, distinct	Translucent.	Fuses with intumescence; gelatinizes with HCl.
5.5	Brittle.	2.9	V. Glassy crystals, sometimes radiate.	Basal, distinct.	Translucent.	Fuses with intumescence; much water; gelatinizes with HCl; colors flame bright green.
5.	Very brittle.	3.1	III. Prisms, and massive or granular.	Basal, imperfect.	Transparent to opaque.	Fuses with difficulty; reaction for phosphorous with magnesium; soluble in acids.
5.5	Brittle.	3.5	V. Crystals and cleavable masses.	Prismatic, distinct.	Transparent to opaque.	Fuses with intumescence; reaction for titanium.

Analytical Key.				Species.	Composition.	Lustre.	Color.	Streak.
V. Streak White or Gray.—Continued.	4. Very Hard.	G. above 4.	Crystallization distinctly prismatic, columnar or bladed.	Light colored and feldspathic. No water.	Wernerite (58).	$CaAl_2Si_2O_8$.	Vitreous.	White, gray, reddish, etc.	White.
					Cancrinite (59).	$Na_2Al_2Si_2O_8 + H_2O$ & CO_2.	Vitreous.	White, gray, yellow, red, green, blue, etc.	White.
		G. below 4.—Continued.		Mainly dark colored and non-feldspathic. No water.	Enstatite (47).	$MgSiO_3$.	Vitreous to pearly.	Grayish and greenish to brown.	White to gray.
					Pyroxene (47).	$(CaMgAl Fe)SiO_3$.	Vitreous.	Green to gray, brown, black, white.	Gray to greenish.
					Amphibole (49).	$(CaMgAl Fe)SiO_3$.	Vitreous.	Green to white, gray, brown, black.	Gray to greenish.
	3. Hard.—Continued.	G. below 4.—Continued.		G. above 3.5 Much water.	Calamine (69).	$Zn_2SiO_4 + H_2O$.	Vitreous.	White.	White.
				G. below 2.5 Much water.	Apophyllite (70).	$4(H_2CaSi_2O_6) + KF$.	Vitreous to pearly.	White to yellowish or greenish.	White.
					Chabazite (73).	$K_2CaAl_2Si_5O_{15} + H_2O$	Vitreous.	White to red.	White.
					Gmelinite (73).	$Na_2Al_2Si_4O_{12} + 6H_2O$.	Vitreous.	White to greenish, reddish, etc.	White.
					Heulandite (74).	$CaAl_2Si_6O_{16} + 5H_2O$.	Vitreous to pearly.	White to red, gray, etc.	White.
		G. above 4.		G. 6.8	Cassiterite (26).	SnO_2.	Adamantine.	Brown to black and gray.	Gray to white.
				G. 4.2	Rutile (26).	TiO_2.	Adamantine.	Brown to red.	Gray to brown.
		G. below 4.		Yellowish and brownish green to dark brown.	Epidote (55).	$H_2Ca_4FeAl_2Si_6O_{26}$.	Vitreous.	Yellowish green to dark brown.	Gray.
					Vesuvianite (54).	$(CaMg)_8(AlFe)_4Si_7O_{28}$.	Vitreous.	Brown to green.	White.
					Compare *Enstatite, Pyroxene, Amphibole, Hypersthene, etc.*				

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5·5	Brittle.	2.7	II. Prismatic, cleavable.	Prismatic, distinct.	Transparent to opaque.	Fuses with intumescence.
5·5	Brittle.	2.5	III. Usually massive.	Prismatic.	Translucent.	Fuses with intumescence; yields water; effervesces with HCl.
5·5	Rather brittle.	3.2	IV. Also massive and lamellar.	Prismatic.	Translucent to opaque.	Infusible and insoluble.
5·5	Brittle.	3.4	V. Often massive and granular.	Prismatic.	Translucent to opaque.	Fusible; insoluble.
5·5	Brittle.	3.2	V. Often bladed or massive.	Prismatic.	Translucent to opaque.	Fusible; insoluble.
4·75	Brittle.	3.6	IV. Also massive and granular.	Prismatic, perfect.	Transparent to opaque.	Infusible; yields water; green color with cobalt solution; gelatinizes with HCl.
4·75	Brittle.	2.4	II. Square crystals, also massive.	Basal, perfect.	Transparent, rarely opaque.	Fuses; colors flame violet; yields water; reacts for fluorine.
4·5	Brittle.	2.1	III. Rhombohedrons.	Rhombohedral distinct.	Transparent to translucent.	Fuses with intumescence; yields water.
4·5	Brittle.	2.1	III. Always in hexagonal crystals.	Prismatic, perfect.	Transparent to translucent.	Fuses with intumescence; much water; gelatinizes with HCl.
4·	Brittle.	2.2	V. Also globular and granular.	Clinopinacoidal, perfect.	Transparent to opaque.	Fuses with intumescence; yields water.
6.5	Brittle.	6.8	II. Square prisms, botryoidal and massive.	Indistinct.	Translucent to opaque.	Infusible and insoluble with soda on charcoal gives tin.
6.5	Brittle.	4.2	II. Usually in twins.	Prismatic, distinct.	Translucent to opaque.	Infusible and insoluble; reactions for titanium.
6.5	Brittle.	3.4	V. Cystals slender or acicular.	Orthopinacoidal, perfect.	Transparent to opaque. Pleochroic.	Fuses with intumescence to a magnetic mass.
6.5	Brittle.	3.4	II. Square prisms, often divergent or irregular.	Indistinct.	Translucent.	Fuses with intumescence.

Analytical Key.			Species.	Composition.	Lustre.	Color.	Streak.
V. *Streak White or Gray.—Continued.* / *4. Very Hard.—Continued.* / *G. below 4. Continued.* / Crystallization distinctly prismatic, columnar or bladed.—Continued.		White, gray, light brown, blue, reddish, etc.	**Diaspore** (29).	$Al_2O_3 + H_2O$.	Pearly to vitreous.	White to gray and brown.	White.
			Cyanite (63).	Al_2SiO_5.	Vitreous to pearly.	Blue to white, also green to gray.	White.
			Fibrolite (63).	Al_2SiO_5.	Vitreous.	Brown to gray, white, green, etc.	White.
			Zoisite (55).	$H_2Ca_4Al_6Si_6O_{26}$.	Vitreous to pearly.	Gray, brown greenish, red.	White.
	Compact, showing no trace of crystalline form or cleavage.	Not easily or distinctly scratched by vitreous quartz.	**Quartz** (Chalcedony, Carnelian, Chrysoprase, etc.) (33).	SiO_2.	Waxy.	White, gray, brown, red, green, etc.	White.
			Quartz (Agate, Onyx, etc.) (33).	SiO_2.	Waxy.	Like chalcedony, but banded, clouded, or dendritic.	White.
			Quartz (Jasper, etc.) (33)	SiO_2.	Waxy to dull.	Red, brown, yellow, green, black, etc.	White to gr
			Quartz (Flint, Chert, etc.) (33). Compare *Vitreous and Milky Quartz.*	SiO_2.	Waxy to dull.	Gray, brown, black.	White to gr
		Bright blue.	**Turquois** (38).	$Al_2P_2O_{11} + 5H_2O$.	Waxy to dull.	Sky-blue to apple-green.	White to green
		Green.	**Epidote** (55).	$H_2Ca_4FeAl_2Si_6O_{26}$.	Vitreous.	Yellowish green.	Gray.
			Amphibole (49). (Jade and Nephrite.) Compare *Chrysolite.*	$(CaMgFe)SiO_3$.	Vitreous.	Deep green to greenish white.	Gray.
		Red to brown Weathers black. G. 3.5	**Rhodonite** (48).	$MnSiO_3$.	Vitreous.	Red, brown, gray.	White.
		Yellow to brown. In grains.	**Chondrodite** (61).	$Mg_8Si_3O_{14}$.	Vitreous to resinous.	Yellow, brown, red, greenish.	White to gr
		Gray to yellowish or greenish. G. 3.3	**Zoisite** (55).	$H_2Ca_4Al_6Si_6O_{26}$.	Vitreous to dull.	Gray to brown.	White.
		Gray, reddish, etc. G. 2.5 to 2.75	**Feldspar family** (60).	See next table.	Vitreous to dull.	Various colors.	White to gr

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5.5	Brittle.	3.4	IV. Usually bladed, foliated or massive.	Brachypinacoidal, perfect.	Translucent.	Infusible; decrepitates strongly; blue color with cobalt solution; insoluble.
7.	Brittle.	3.6	VI. Coarsely bladed.	Pinacoidal, distinct.	Translucent.	Infusible and insoluble; blue color with cobalt solution.
6.5	Brittle.	3.2	V. Usually slender to bladed or fibrous.	Orthopinacoidal, perfect.	Translucent.	Like cyanite.
6.5	Brittle.	3.3	IV. Slender and deeply striated.	Brachypinacoidal, perfect.	Translucent.	Swells up and fuses.
7.	Brittle.	2.6	III. Botryoidal, stalactitic, etc.	Conchoidal.	Translucent.	Infusible and insoluble in acids; dissolves with effervescence in soda.
7.	Brittle.	2.6	III. Botryoidal, geoditic etc.	Conchoidal.	Translucent.	Like chalcedony.
7.	Brittle.	2.6	III. Compact, banded, etc.	Conchoidal.	Opaque.	Like chalcedony.
7.	Brittle.	2.6	III. Usually in irregular nodules.	Conchoidal.	Translucent to opaque.	Like chalcedony.
6.	Brittle.	2.7	Amorphous, incrusting.	None.	Opaque.	Infusible; but yields water and turns brown; soluble in HCl.
6.5	Brittle.	3.4	V. Compact to finely granular.	None.	Opaque.	Fuses with intumescence to a magnetic mass.
6.	Tough.	3.2	V. Compact.	None.	Translucent.	Fusible; insoluble.
6.	Tough.	3.5	VI. Compact to finely crystaline.	None.	Translucent to opaque.	Fusible; amethystine bead with borax.
6.5	Brittle.	3.2	V. and IV. Usually in rounded grains.	None.	Translucent to opaque.	Infusible; gelatinizes with HCl.
6.5	Brittle.	3.3	IV. Compact to finely crystalline.	None.	Translucent to opaque.	Swells up and fuses.
6.5	Brittle.	2.7	V. and VI. Compact and porphyritic.	None.	Opaque.	Fuses with difficulty; weathers white.

Analytical Key.		Species.	Composition.	Lustre.	Color.	Streak.
V. Streak White or Gray.—Continued. 4. Very Hard.—Continued. G. below 4.—Continued. Crystalline or cleavable.		Epidote (55).	$H_2Ca_4FeAl_2Si_6O_{26}$.	Vitreous.	Yellowish green to dark brown.	Gray.
	Slender or prismatic.	Vesuvianite (54).	$(CaMg)_8(AlFe)_4Si_7O_{28}$.	Vitreous.	Brown to green.	White.
		Zoisite (55).	$H_2Ca_4Al_6Si_6O_{26}$.	Vitreous.	Gray to brown, greenish to red.	White.
	Green.	Chrysolite (52).	$(MgFe)_2SiO_4$.	Vitreous.	Green.	White.
		Prehnite (69).	$H_2CaAl_2Si_3O_{12}$.	Vitreous.	Green to white or gray.	White.
		Spodumene (Hiddenite) (48).	$Li_6Al_8Si_{15}O_{45}$.	Vitreous to pearly.	Gray to green.	White.
		Orthoclase (60). (Amazon Stone.)	$K_2Al_2Si_6O_{16}$.	Vitreous.	Green.	White.
	Red, yellow or brown.	Rhodonite (48).	$MnSiO_3$.	Vitreous.	Red to brown and gray.	White.
		Quartz (rose, amethystine, smoky and ferruginous). (33).	SiO_2.	Vitreous.	Purple, red, yellow, brown, etc.	White.
		Chondrodite (61).	$Mg_8Si_3O_{14}$.	Vitreous to resinous.	Yellow, red, brown, greenish.	White to gray.
		Orthoclase (60).	$K_2Al_2Si_6O_{16}$.	Vitreous.	White, gray, red, green, etc.	White.
	No cleavage.	Quartz (33).	SiO_2.	Vitreous.	All colors and colorless.	White.
	Cleavable obliquely. G. above 3.	Spodumene (48).	$Li_6Al_8Si_{15}O_{45}$.	Vitreous to pearly.	Gray to green.	White.
	Cleavable at right angles. G. below 3.	Feldspars (60). Orthoclase.	$K_2Al_2Si_6O_{16}$.	Vitreous.	White to gray, etc.	White.
		Feldspars (60). Albite.	$Na_2Al_2Si_6O_{16}$.	Vitreous to pearly.	White.	White.
		Feldspars (60). Oligoclase.	$(Na_2Ca)Al_2Si_5O_{14}$.	Vitreous to pearly.	White, gray to greenish and reddish.	White.
		Feldspars (60). Labradorite. Compare *Nephelite*.	$(Na_2Ca)Al_2Si_3O_{10}$.	Vitreous to pearly.	Gray to greenish.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
5.5	Brittle.	3.4	V. Slender prisms.	Orthopinacoidal, perfect.	Transparent to opaque. Pleochroic.	Fuses with intumescence to a magnetic mass.
6.5	Brittle.	3.4	II. Square prisms often divergent.	Indistinct.	Translucent.	Fuses with intumescence.
6.5	Brittle.	3.3	IV. Slender prisms deeply striated.	Brachypinacoidal, perfect.	Translucent.	Swells and fuses.
6.5	Brittle.	3.4	IV. Usually in grains or granular.	Conchoidal.	Translucent.	Infusible; gelatinizes with HCl.
6.5	Brittle.	2.9	IV. Often with crested surface.	Basal, distinct.	Translucent.	Fusible with intumescence; yields water.
6.75	Brittle.	3.15	V. Large prismatic crystals.	Prismatic, perfect.	Transparent to opaque.	Fuses with red flame and intumescence.
6.	Brittle.	2.5	V. Crystals and cleavable masses.	Basal and clinopinacoidal, perfect.	Translucent.	Fusible with difficulty; insoluble.
6.	Tough.	3.5	Compact to finely crystalline.	None.	Translucent to opaque.	Fusible; amethystine bead with borax.
7.	Brittle.	2.65	III. Prisms pyramids and massive.	Conchoidal.	Transparent to translucent.	Infusible and insoluble in acid; dissolves with effervescence in soda.
6.5	Brittle.	3.2	V. and IV. Usually in grains.	None.	Translucent to opaque.	Infusible; gelatinizes with HCl.
6.	Brittle.	2.5	V. Crystals and cleavable masses.	Basal and clinopinacoidal, perfect.	Transparent to translucent	Fusible with difficulty; insoluble.
7.	Brittle.	2.65	III. Prisms, pyramids and massive.	Conchoidal.	Transparent to translucent	Infusible and insoluble in acid; dissolves with effervescence in soda.
6.75	Brittle.	3.15	V. Prisms and cleavable masses.	Prismatic, perfect.	Translucent to opaque.	Fuses with reddish flame and intumescence.
6.	Brittle.	2.5	V. Crystals and cleavable masses.	Basal and clinopinacoidal, perfect.	Transparent to translucent.	Fusible with difficulty; insoluble.
6.5	Brittle.	2.6	VI. Commonly massive.	Like orthoclase.	Transparent to translucent.	Fusible with difficulty; insoluble.
6.5	Brittle.	2.65	VI. Usually massive.	Like orthoclase.	Transparent to translucent.	Fusible with difficulty; insoluble.
6.	Brittle.	2.7	VI. Cleavable to massive.	Like orthoclase.	Transparent to translucent.	Fusible with difficulty; insoluble.

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V. *Streak White or Gray.—Continued.*

5. *Adamantine.*

Analytical Key.				Species.	Composition	Lustre.	Color.	Streak.
H. above 8. Scratch beryl.	H. 10	Isometric.		**Diamond** (5).	C.	Adamantine brilliant.	White or colorless to yellowish, reddish, etc.	White.
	H. 9	Hexagonal.		**Corundum** (25).	Al_2O_3.	Vitreous.	Gray, brown, red, yellow, blue, black, etc.	White.
	H. 8.5	Orthorhombic.		**Chrysoberyl** (24).	$BeAl_2O_4$.	Vitreous.	Green.	White.
H. not above 8, do not scratch beryl distinctly.	Octahedrons.	Black to red.		**Spinel** (23).	$MgAl_2O_4$.	Vitreous.	Black, red, blue, green, yellow, etc.	White.
	Dodecahedrons and Tetrag. trisect.	Chiefly red, yellow or brown.		**Garnet** (53).	$(CaFeMnMg)_3(AlFe)_2Si_3O_{12}$.	Vitreous.	All colors, often bright.	White.
	Square prisms and pyramids.	Adamantine, usually bright.		**Zircon** (26).	$ZrSiO_4$.	Vitreous.	Gray, yellowish, brownish, etc.	White.
		Vitreous, usually weak.		**Andalusite** (63).	Al_2SiO_5.	Vitreous to dull.	White, gray, red, green, brown.	White.
	Triangular prisms and rhombohedrons.	Chiefly black.		**Tourmaline** (62).	Complex silicate.	Vitreous.	Black, red, green, blue, etc.	White to gray.
	Rhombic prisms.	Perfect basal cleavage.		**Topaz** (64).	$Al_2SiO_4F_2$.	Vitreous.	Yellow, white, green, blue, red, etc.	White.
		No basal cleavage.		**Staurolite** (66).	$MgFe_2Al_{12}Si_6O_{34}$.	Vitreous to resinous.	Dark brown to black.	White to gray.
	Green.	Hexagonal prisms.		**Beryl** (50).	$Be_3Al_2Si_6O_{18}$.	Vitreous.	Green to yellow and white.	White.

H.	Tenacity.	G.	Form.	Cleavage.	Other Properties.	Confirmatory Chemical Tests.
10	Brittle.	3.5	I. Usually with curved faces.	Octahedral, perfect.	Transparent.	Burns at a high temperature; insoluble.
9.	Brittle to tough.	4.	III. Also massive to finely granular.	Basal and rhombohedral.	Transparent to translucent.	Infusible and insoluble.
8.5	Brittle.	3.7	IV. Usually in hexagonal twins.	Imperfect.	Transparent to translucent.	Infusible aud insoluble.
8.	Brittle.	3.8	I. Octahedrons and water-worn grains.	Octahedral.	Transparent to opaque.	Infusible and insoluble.
7.5	Brittle.	3.2 to 4.3	I. Distinct crystals, rarely granular.	Imperfect.	Transparent to opaque.	Fusible, usually to a magnetic globule; insoluble.
7.5	Brittle.	4.4	II. Rarely irregular grains.	Imperfect.	Transparent to opaqne.	Infusible and insoluble.
7.5	Brittle.	3.2	IV. Usually a black square or cross on section.	Imperfect.	Transparent to opaque.	Infusible and insoluble.
7.5	Brittle.	3.1	III. Rarely massive.	None.	Transparent to opaque.	Mostly infusible; insoluble.
8.	Brittle.	3.5	IV. Rarely massive or granular.	Basal, perfect.	Transparent to opaque.	Infusible and insoluble; blue color with cobalt solution; fluorine reaction.
7.25	Brittle.	3.6	IV. Usually in cruciform twins.	Imperfect.	Translucent to opaque.	Infusible and insoluble.
8.	Brittle.	2.7	III. Rarely massive.	Imperfect.	Transparent to translucent.	Infusible and insoluble.

HOW TO USE THE TABLES.

The plan of these Tables, and the method of using them in determining minerals, have been explained incidentally in the introduction; but a more connected statement will probably be useful to many students. Minerals are divided at the outset into two great classes, *metallic* and *non-metallic*. Each class comprises five subclasses, the metallic subclasses being distinguished accordnig to the *colors* of the species, and the non-metallic subclasses according to the *streaks*, or colors of the powdered minerals. The species in each subclass are furthur distinguished according to hardness as *very soft, soft, hard, very hard* and, in the fifth non-metallic subclass, *adamantine*. We thus by (1) the lustre, (2) the color or streak and (3) the hardness, of minerals divide them into forty-one groups, as shown in the general classification on page 25. This synopsis of the tables also obviates the necessity of continually turning the pages, as it enables us to turn at once to the page on which the mineral in hand is described.

In the analytical key on the left margin of each table these groups are subdivided in accordance with other and various physical properties until we come to the individual species, or groups of two or three species only, in the next column to the right. While in the succeeding columns we find, besides the composition, a concise physical description of each species, by which it may be more carefully distinguished from those most closely resembling it, and the identification verified; and, finally, the broad column on the right margin contains a brief statement of the chemical tests, which are our last resort, to be tried only when the determination is not otherwise satisfactory.

To make the method of using the tables still clearer, a single example is appended, using a fragment of galenite. Turning to the general classification on page 25, we observe first that it is *metallic*, and take the left column; next that it is not red, brown, yellow or black, but *gray*, belonging in the fourth subclass; and then, trying the hardness with steel, find that it cuts easily and is *soft;* and turn to page 38 for the detailed analysis of this group. Here the six species in this group are divided by the streak into three subgroups, and on testing the specimen it is found to belong to the second, having a *dark gray streak*. This subgroup includes three species—stibnite, galenite and chalcocite; and on glancing over the physical descriptions to the right it is seen that, while they agree closely in certain properties, they are easily distinguished by others, especially by color, density, form and cleavage. If, however, the specimen is of an impure or doubtful character, fusion on charcoal will show that it gives reactions for lead, but not for antimony or copper.

In all cases where the meaning of the tables is not clear, the student should refer to the section of the introduction where the property or test is explained and it may be fairly said that the golden rule in determinative mineralogy is to *follow the order of the tables*, and not skip about, or guess at the names or relations of minerals.

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